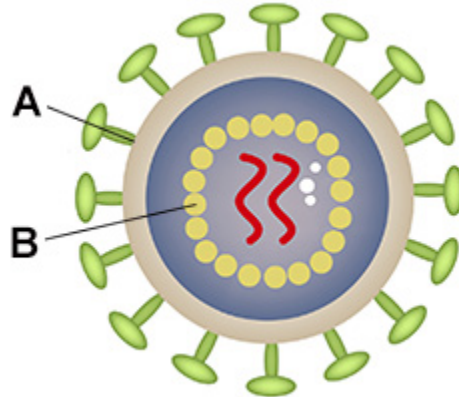


**Q1.**

The diagram below shows the structure of the human immunodeficiency virus (HIV).



(a) Name structures **A** and **B**.

**A** \_\_\_\_\_

**B** \_\_\_\_\_

(2)

(b) Describe how HIV is replicated.

---



---



---



---



---



---



---



---



---



---

(4)

(Total 6 marks)

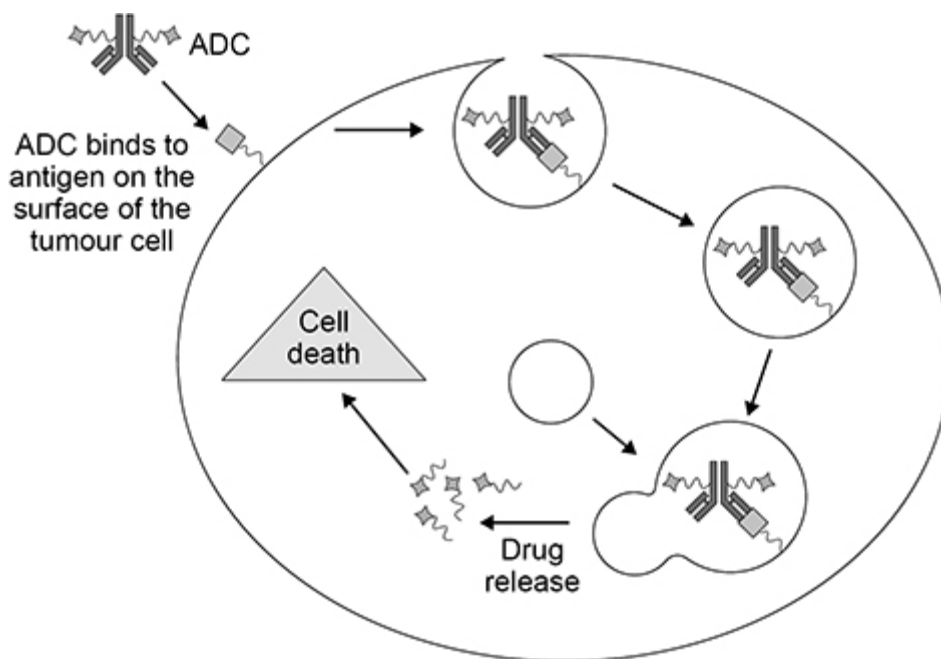
**Q2.**

- (a) ADCs are molecules made of a monoclonal antibody linked to a cancer drug.

**Figure 1** shows how an ADC enters and kills a tumour cell.

The process of entering the cell and the breakdown of the antibody to release the drug is very similar to phagocytosis.

**Figure 1**



Use your knowledge of phagocytosis to describe how an ADC enters and kills the tumour cell.

---



---



---



---



---



---



---



---



---



---

(3)

- (b) Some of the antigens found on the surface of tumour cells are also found on the surface of healthy human cells.

Use this information to explain why treatment with an ADC often causes side effects.

---

---

---

---

---

---

---

(2)

Scientists investigated whether one type of ADC could be used to treat human breast cancer.

This ADC is a monoclonal antibody combined with a drug to inhibit mitosis. The monoclonal antibody binds to a protein found on human breast cancer cells.

The scientists placed small pieces of human breast cancer tissue under the skin of mice.

The scientists then randomly divided the mice into three groups. They treated the groups as follows on day 0.

**Group G** – control

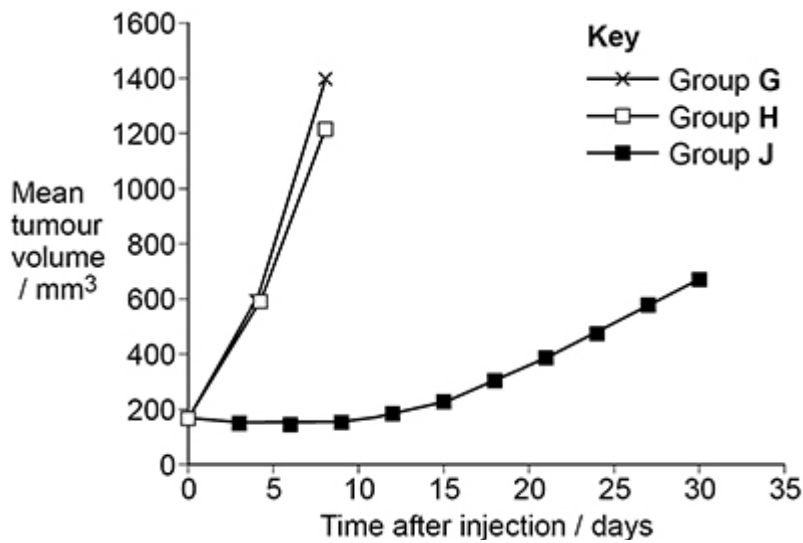
**Group H** – injected with monoclonal antibody only

**Group J** – injected with ADC (monoclonal antibody + drug).

Every few days, the scientists measured the volume of the tumours formed from the human breast cancer tissue.

Figure 2 shows the scientists' results.

Figure 2



- (c) Mice in **Group H** were injected with  $2 \text{ mg kg}^{-1}$  of monoclonal antibody. The monoclonal antibody was in a solution of concentration  $500 \text{ mg dm}^{-3}$

Calculate the volume of antibody solution that the scientists would have injected into a 23 g mouse. Give your answer in  $\text{dm}^3$  and in standard form.

\_\_\_\_\_  $\text{dm}^3$  (2)

- (d) Suggest **one** reason why there are no data for **Group G** and **Group H** after day 8

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(1)

- (e) Suggest and explain **two** further investigations that should be done before this ADC is tested on human breast cancer patients.

1 \_\_\_\_\_

\_\_\_\_\_

2 \_\_\_\_\_

\_\_\_\_\_

(2)

(Total 10 marks)

**Q3.**

- (a) Describe how the human immunodeficiency virus (HIV) is replicated **once inside** helper T cells ( $T_H$  cells).

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(4)

HIV-1 is the most common type of HIV. HIV-1 binds to a receptor on  $T_H$  cells called CCR5.

Current treatment for HIV-1 involves the use of daily antiretroviral therapy (ART) to stop the virus being replicated. Only 59% of HIV-positive individuals have access to ART.

Scientists have found that two HIV-1-positive patients (**P** and **Q**) have gone into remission (have no detectable HIV-1). This happened after a blood stem cell transplant (BSCT).

- Patient **P** was given **two** BSCTs, and patient **Q** was given **one** BSCT.
- All BSCTs came from a donor with T<sub>H</sub> cells **without** the CCR5 receptor.
- In addition, patient **P** had radiotherapy, and patient **Q** had chemotherapy. Both of these treatments are toxic.
- **Both** patients (**P and Q**) stopped receiving ART 16 months after BSCT.

18 months after stopping ART, **both** patients had **no** HIV-1 RNA in their plasma, **no** HIV-1 DNA in their T<sub>H</sub> cells and **no** CCR5 on their T<sub>H</sub> cells.

- (b) Use the information given to evaluate the use of BSCT to treat HIV infections.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

(5)  
(Total 9 marks)

**Q4.**

- (a) Describe how a phagocyte destroys a pathogen present in the blood.

---

---

---

---

---

---

---

---

---

---

---



---

(3)

(b) Give **two** types of cell, other than pathogens, that can stimulate an immune response.

1

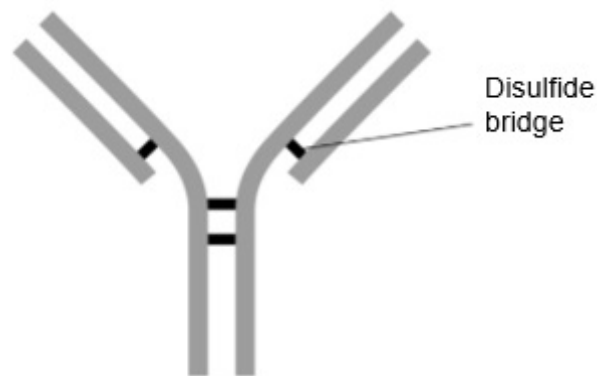
---

2

---

(2)

(c) The diagram below shows the structure of an antibody.



Label the diagram above with an **X** to show where an antigen-antibody complex forms.

(1)

(d) A disulfide bridge is labelled in the diagram above.

What is the role of the disulfide bridge in forming the quaternary structure of an antibody?

---



---



---



---

(1)

(Total 7 marks)

**Q5.**

- (a) Explain how HIV affects the production of antibodies when AIDS develops in a person.

---



---



---



---



---



---



---



---



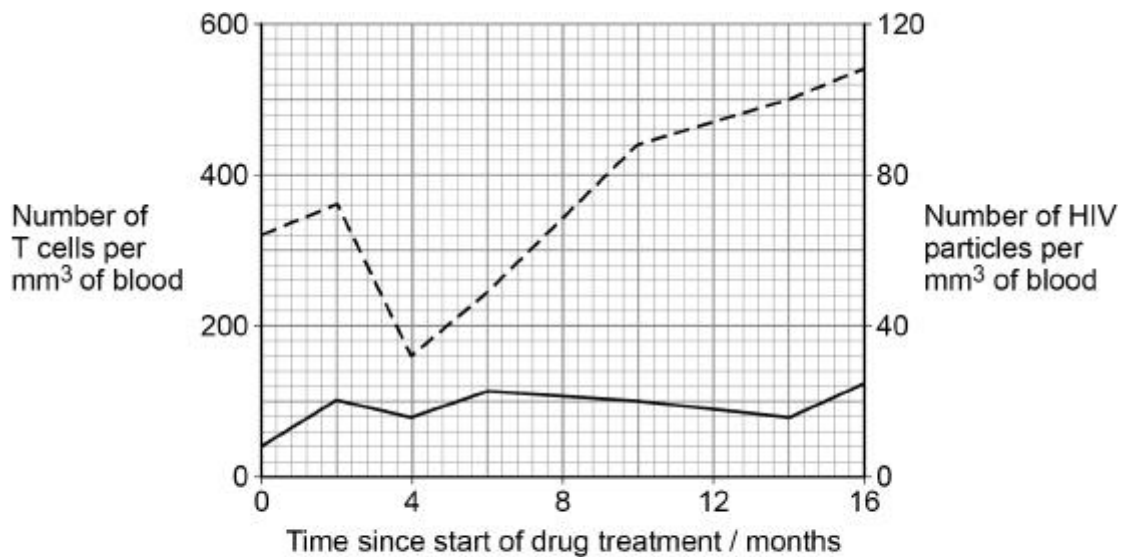
---



---

(3)

- (b) A scientist measured the effect of a drug on the number of T cells and the number of HIV particles in blood taken from a person with AIDS. The results are shown on the graph below.



**Key**

- T cells
- HIV particles

Symptoms of AIDS occur when the number of T cells is below 200 cells mm<sup>-3</sup>



Use all of this information to evaluate the effectiveness of the drug in treating AIDS.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

**(5)**  
**(Total 8 marks)**

**Q6.**

In Europe, viruses have infected a large number of frogs of different species. The viruses are closely related and all belong to the Ranavirus group.

Previously, the viruses infected only one species of frog.

- (a) Suggest and explain how the viruses became able to infect other species of frog.

---

---

---

---

---

---

---

---

---

---

**(2)**

- (c) Determining the genome of the viruses could allow scientists to develop a vaccine.

Explain how.

---

---

---

---

---

---

---

(2)

- (d) Describe how the B lymphocytes of a frog would respond to vaccination against Ranavirus.

You can assume that the B lymphocytes of a frog respond in the same way as B lymphocytes of a human.

Do **not** include details of the cellular response in your answer.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

(3)

**Q7.**

(a) What is a **monoclonal** antibody?

---



---



---



---

(1)

(b) After a disease is diagnosed, monoclonal antibodies are used in some medical treatments.

Give **one** example of using monoclonal antibodies in a medical treatment.

---



---



---

(1)

(c) Describe the role of antibodies in producing a positive result in an ELISA test.

---



---



---



---



---



---



---



---



---



---



---



---

(4)

(Total 6 marks)

**Q8.**

- (a) Describe and explain the role of antibodies in stimulating phagocytosis.

Do **not** include details about the process of phagocytosis.

---

---

---

---

---

---

---

---

---

---

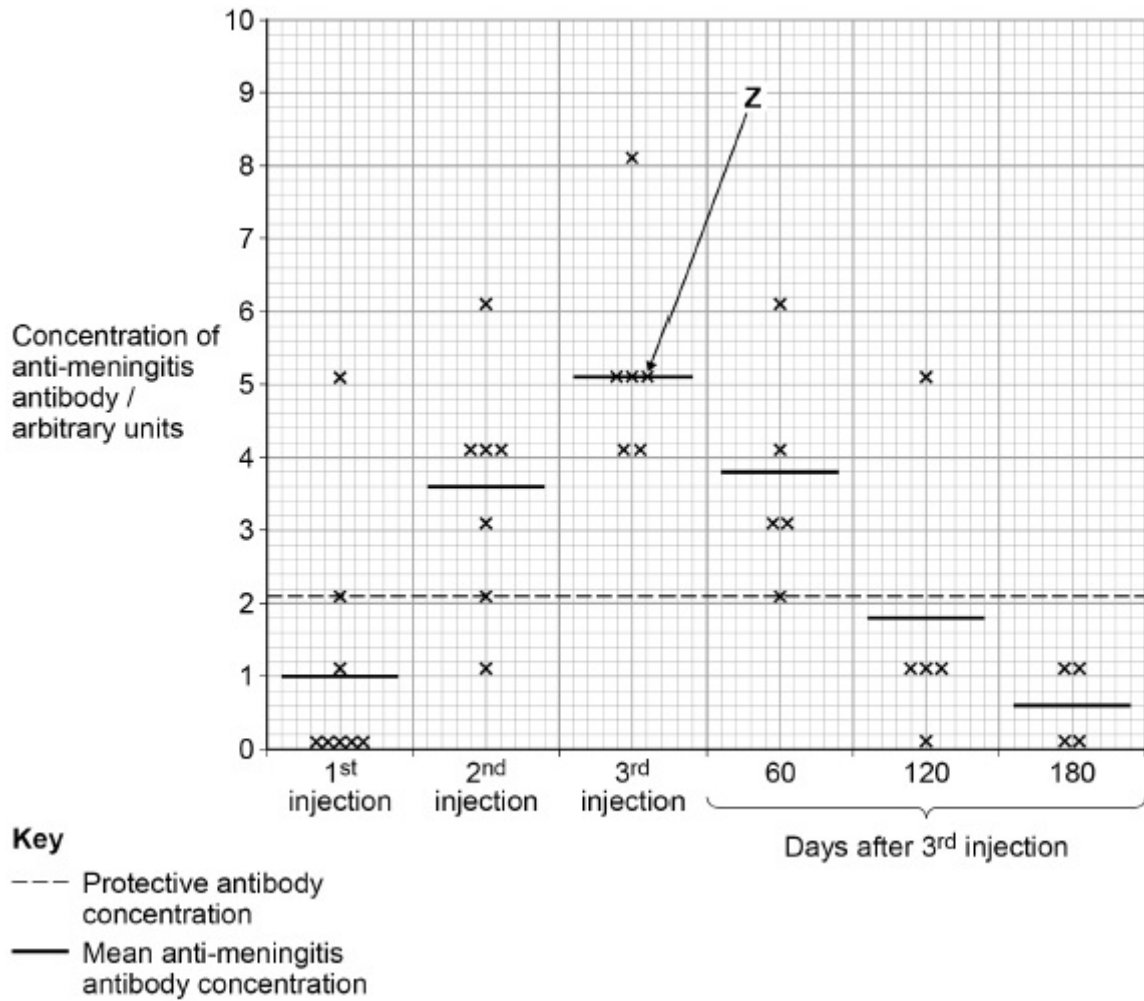
(2)

*Meningococcus* bacteria cause a disease called meningitis. Scientists investigated a new meningitis vaccine (MenG) by measuring changes in blood anti-meningitis antibody concentration in mice.

Each mouse was given three separate MenG injections. The concentration of anti-meningitis antibody was measured in a sample of blood taken soon after each injection.

After the 3rd injection, the concentration of anti-meningitis antibody in the blood was also measured after 60 days, after 120 days and then after 180 days.

The graph shows the scientists' results. Each plotted point on the graph is the result for a different mouse.



- (b) The scientists discovered that the concentration of anti-meningitis antibody of the mouse labelled **Z** in the graph above decreased after the 3<sup>rd</sup> injection at a constant rate of 0.027 arbitrary units per day.

Use this information and the graph to calculate the number of days after the 3<sup>rd</sup> injection the antibody concentration is higher than the protective antibody concentration for this mouse.

Answer = \_\_\_\_\_ days

(2)

- (c) Using the graph above, what can you conclude about the effectiveness of each injection on the immune response of these mice?

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

(4)

- (d) The scientists hypothesised that memory B cells had formed in the mice 180 days after the 3rd injection.

Suggest and explain a practical method the scientists could use to test this hypothesis.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

(2)

(Total 10 marks)

**Q9.**

- (a) When a person is bitten by a venomous snake, the snake injects a toxin into the person. Antivenom is injected as treatment. Antivenom contains antibodies against the snake toxin. This treatment is an example of passive immunity.

Explain how the treatment with antivenom works and why it is essential to use passive immunity, rather than active immunity.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

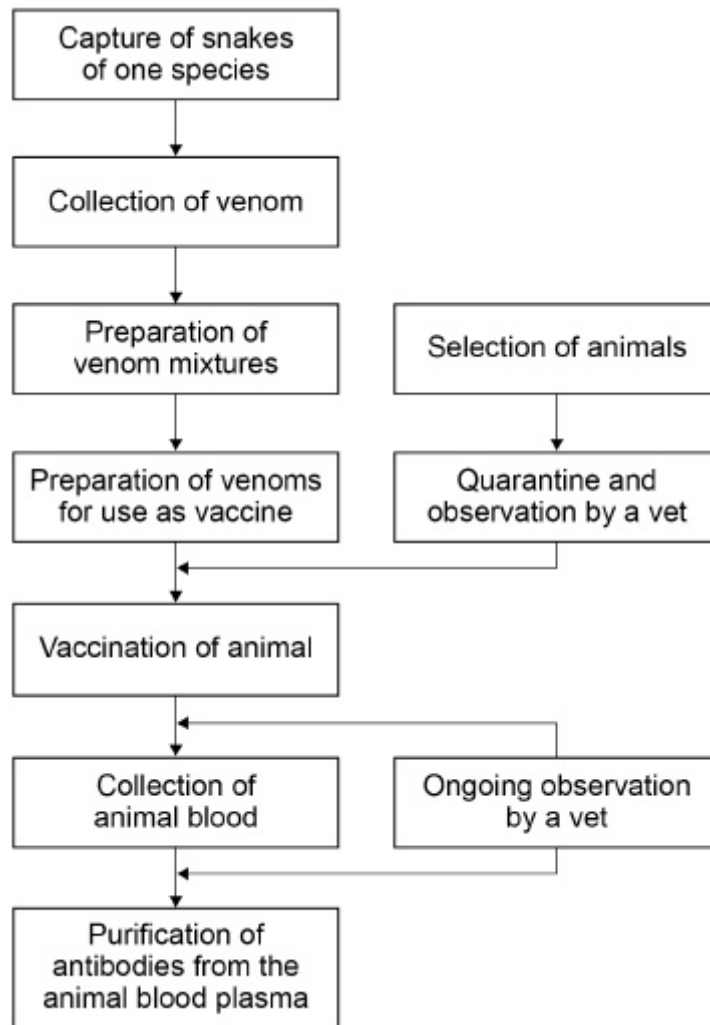
---

---

---

(2)

The chart shows a procedure used to produce antivenom.



(b) A mixture of venoms from several snakes of the same species is used.

Suggest why.

---



---



---



---



---



---

(2)



- (c) Horses or rabbits can be used to produce antivenoms.  
When taking blood to extract antibody,  $13 \text{ cm}^3$  of blood is collected per kg of the animal's body mass.  
The mean mass of the horses used is 350 kg and the mean mass of the rabbits used is 2 kg

Using only this information, suggest which animal would be better for the production of antivenoms.  
Use a calculation to support your answer.

---

---

---

---

---

---

---

---

---

---

(2)

- (d) During the procedure shown in the chart the animals are under ongoing observation by a vet.  
Suggest **one** reason why.

---

---

---

---

---

---

---

---

---

---

(1)

- (e) During vaccination, each animal is initially injected with a small volume of venom. Two weeks later, it is injected with a larger volume of venom.

Use your knowledge of the humoral immune response to explain this vaccination programme.

---



---



---



---



---



---



---



---



---



---



---

(3)

(Total 10 marks)

### Q10.

Read the following passage.

Azidothymidine (AZT) is a drug used to treat people infected with human immunodeficiency virus (HIV). It inhibits the enzyme that synthesises DNA from HIV RNA. This does not destroy HIV in the body but stops or slows the development of AIDS.

- 5 In the past, some people who took AZT on its own eventually developed AIDS. Some of the HIV in their bodies had become resistant to AZT. To prevent this from happening, people infected with HIV are now treated with highly active antiretroviral therapy (HAART). This involves taking AZT with other anti-HIV drugs at the same time.
- 10 AZT is taken in low doses. This is because people who took high doses over long periods of time suffered muscle wastage. It was found that high doses of AZT inhibit replication of mitochondria.

Use information from the passage and your own knowledge to answer the questions.

- (a) Suggest and explain why AZT does not destroy HIV in the body but stops or slows the development of AIDS (lines 3–4).

---

---

---

---

---

---

---

---

---

---

(4)

- (b) Suggest and explain **two** advantages of using HAART (lines 7–9).

Advantage 1 \_\_\_\_\_

---

---

---

---

Advantage 2 \_\_\_\_\_

---

---

---

---

(4)

**Q11.**

(a) Describe how phagocytosis of a virus leads to presentation of its antigens.

---

---

---

---

---

---

---

---

---

---

**(3)**

(b) Describe how presentation of a virus antigen leads to the secretion of an antibody against this virus antigen.

---

---

---

---

---

---

---

---

---

---

**(3)**

- (c) Collagen is a protein produced by cells in joints, such as the knee.

Rheumatoid arthritis (RA) is an auto-immune disease. In an auto-immune disease, a person's immune system attacks their own cells. RA causes pain, swelling and stiffness in the joints.

Scientists have found a virus that produces a protein very similar to human collagen.

Suggest how the immune response to this viral protein can result in the development of RA.

---



---



---



---



---

(2)

(Total 8 marks)

**Q12.**

- (a) What is an antigen?

---



---

(2)

- (b) What is an antibody?

---



---

(2)

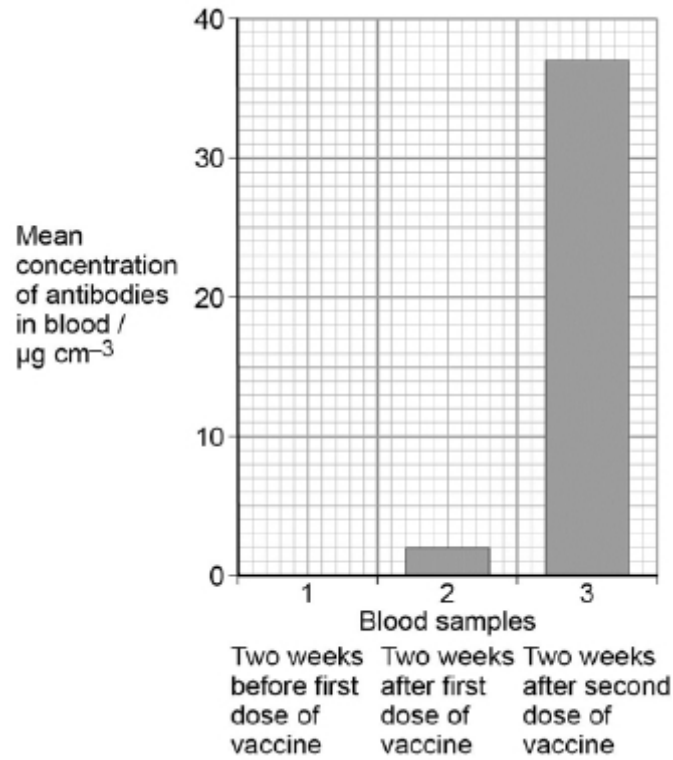
Poliomyelitis is an infection caused by a virus.

A doctor vaccinated a group of patients against poliomyelitis. He gave each patient two doses of vaccine, 3 months apart.

An immunologist tested three samples of blood from each of the patients:

- (sample 1) taken 2 weeks before the first dose of vaccine
- (sample 2) taken 2 weeks after the first dose of vaccine
- (sample 3) taken 2 weeks after the second dose of vaccine.

He measured the concentration of antibodies against the poliomyelitis virus in the patients' blood each time. The results are shown in the graph.



- (c) Calculate the percentage increase in the mean concentration of antibodies in blood between samples 2 and 3.

Answer = \_\_\_\_\_ %

(1)

- (d) Explain the differences between the mean concentrations of antibodies in blood samples 1, 2 and 3.

---



---



---



---



---



---



---



---

(4)

(Total 9 marks)

**Q13.**

Bacterial meningitis is a potentially fatal disease affecting the membranes around the brain. *Neisseria meningitidis* (Nm) is a leading cause of bacterial meningitis.

- (a) In the UK, children are vaccinated against this disease. Describe how vaccination can lead to protection against bacterial meningitis.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

(6)

**Q14.**

- (a) When a vaccine is given to a person, it leads to the production of antibodies against a disease-causing organism. Describe how.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

**(5)**

- (b) Describe the difference between active and passive immunity.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

**(5)**

**(Total 10 marks)**



