Q1. This question should be answered in continuous prose.
Quality of Written Communication will be assessed in the answer.

(i) Starting with mRNA, describe how the process of translation leads to the production of a polypeptide.

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(4)

(ii) Normal tomato plants have an enzyme that softens tomatoes as they ripen. Genetically engineered tomatoes ripen and soften more slowly. A gene was inserted which reduces the amount of softening enzyme produced.

The diagram shows matching parts of the base sequences for the mRNA produced by the gene for the softening enzyme and that produced by the inserted gene.

Softening gene mRNA …AAUCGGAAU…

Inserted gene mRNA …UUAGCCUUA…

Suggest how the inserted gene reduces the production of the softening enzyme.

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(2)
(Total 6 marks)

Q2. (a) What is meant by a gene?

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(2)

The polymerase chain reaction (PCR) can be used to obtain many copies of a particular gene.

(b) Explain how the strands of DNA are separated during the PCR.

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(2)

(c) In a particular PCR, two different primers are added to the DNA.

(i) Why are primers required?

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(1)

(ii) Suggest why two different primers are required.

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(1)

(d) Starting with a single molecule of DNA, the polymerase chain reaction was allowed to go through three complete cycles. How many molecules of DNA would be produced?

Answer .....

(1)
(Total 7 marks)

Q3. (a) Describe how a gene can be isolated from human DNA.

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(2)

(b) Describe how an isolated gene can be replicated by the polymerase chain reaction (PCR).

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(4)

(c) (i) Describe how a harmless virus, genetically engineered to contain a CFTR gene, can be used to insert the gene into a cystic fibrosis sufferer.

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(2)

(ii) A virus used in gene therapy has RNA as its genetic material and has an enzyme called reverse transcriptase. Inside a human cell, reverse transcriptase uses viral RNA to make viral DNA.

Explain why the enzyme is called *reverse transcriptase*.

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(1)

(Total 9 marks)

Q4. Read the following passage.

The giant panda is one of the rarest animals in the world and is considered to be on the brink of extinction in the wild. Giant pandas have been kept and bred in zoos with the hope that they could be released into the wild. One worry is that small populations, like those in zoos, reduce the genetic variation needed to allow the species to adapt to changing conditions. Unfortunately, pandas find it difficult to reproduce in captivity. Fertilisation of the females is guaranteed only by insemination with semen from several males. With so many potential fathers, the true paternity of the cubs is not clear. It is important to identify the fathers to maintain genetic variation.

Panda faeces can be collected in the wild. The faeces contain DNA from the panda, from the bamboo on which they feed and from bacteria. The DNA is subjected to the polymerase chain reaction (PCR). The primers used attach only to the panda DNA. The resulting DNA is subjected to genetic fingerprinting. This can help us to count the number of individuals in the wild because it allows us to identify individual pandas.

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

(a) Describe how genetic fingerprinting may be carried out on a sample of panda DNA.

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(6)

(b) (i) Explain how genetic fingerprinting allows scientists to identify the father of a particular panda cub.

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(2)

(ii) When pandas are bred in zoos, it is important to ensure only unrelated pandas breed. Suggest how genetic fingerprints might be used to do this.

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(1)

(c) (i) Suggest why panda DNA is found in faeces. (line 10)

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(1)

(ii) Explain why the PCR is carried out on the DNA from the faeces. (line 12)

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(1)

(iii) Explain why the primers used in the PCR will bind to panda DNA, but not to DNA from bacteria or bamboo. (line 12)

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(2)

(d) DNA from wild pandas could also be obtained from blood samples. Suggest **two** advantages of using faeces, rather than blood samples, to obtain DNA from pandas.

1 .....

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2 .....

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(2)

(Total 15 marks)

Q5. (a) Plasmids can be modified by genetic engineering and inserted into bacteria. These bacteria can then make useful substances normally made by another organism. Explain how modified plasmids are made by genetic engineering and how the use of markers enable bacteria containing these plasmids to be detected.

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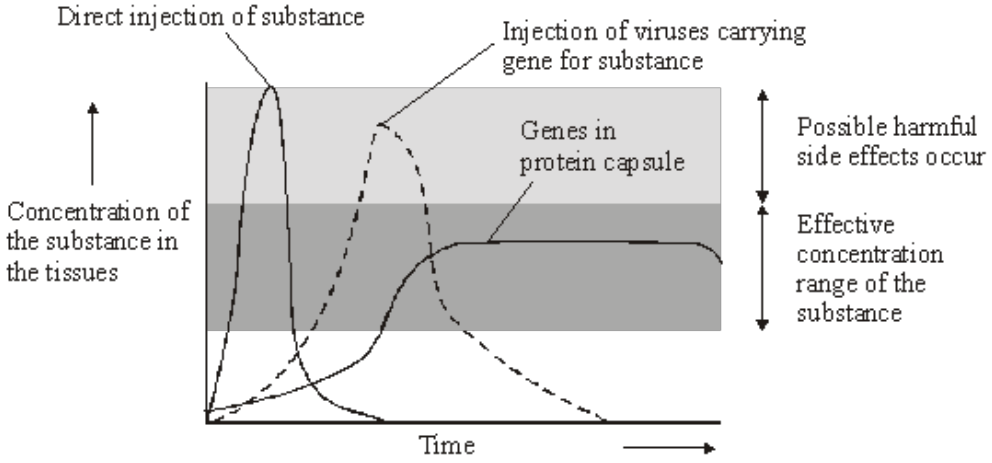
(6)

(b) In gene therapy, genes are introduced into a person who has defective genes which do not produce an important substance. Three experiments were done to compare techniques for introducing an important substance into a person with defective genes.

1. The substance was injected directly.
2. Harmless viruses carrying genes coding for the substance were injected.
3. The genes were put into a protein capsule which was inserted into the tissues.

The graph shows results of the experiments.



Takahiro Ochiya et al, Biomaterials for Gene Delivery: Studies on Metastasis, (National Cancer Centre, Research Institute, Tokyo, Japan) 1999

(i) Describe the results of the three experiments.

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(3)

(ii) Using the information in the graph, suggest **one** advantage and **one** disadvantage of the capsule method compared to the others.

Advantage .....

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Disadvantage .....

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(2)
(Total 11 marks)

Q6. (a) CFTR is a transmembrane regulator protein. Its molecules have 1480 amino acids. People with cystic fibrosis produce defective CFTR protein which is missing one amino acid from its structure.

(i) What is the minimum number of bases on DNA which would code for the normal CFTR protein? Explain your answer.

Number of bases .....

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(2)

(ii) Which type of gene mutation produced the cystic fibrosis allele? Explain your answer.

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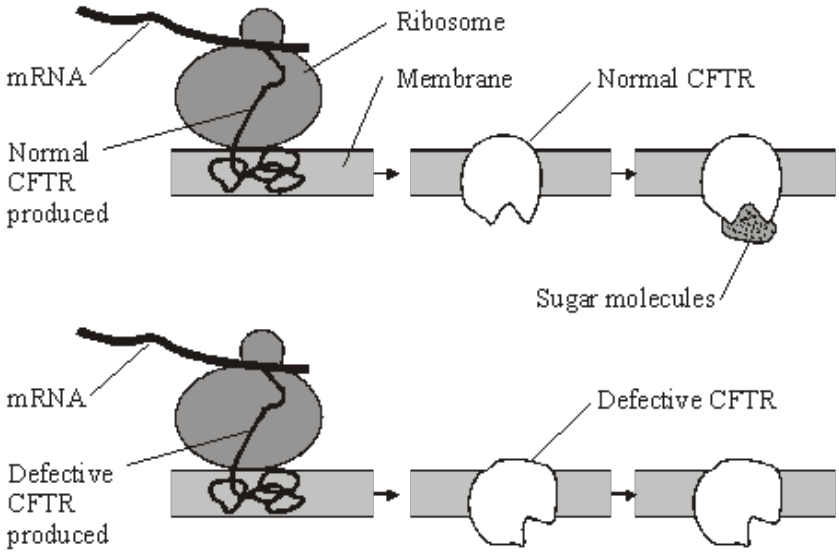
(2)

(b) The diagram shows part of the process of making normal and defective CFTR in a cell. A normal CFTR protein molecule has sugar molecules attached to it which make it functional.



(i) Describe how the information on mRNA is translated into CFTR at the ribosome.

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(4)

(ii) Using information in the diagram and your own knowledge, suggest why defective CFTR, missing one amino acid, is not functional.

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(2)

(Total 10 marks)

Q7. (a) Explain the reason for each of the following in the polymerase chain reaction (PCR).

(i) DNA is heated to 95 °C.

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(1)

(ii) DNA polymerase used is heat-stable.

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(1)

(iii) The reaction mixture is cooled to 40 °C.

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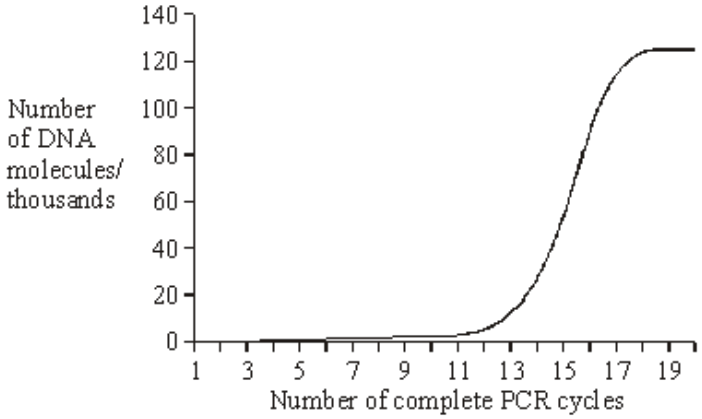
(1)

(b) The graph shows the number of DNA molecules made using PCR, starting with one molecule.



(i) Explain the shape of the curve from cycles 1 to 16.

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(2)

(ii) Suggest **one** explanation for the levelling out of the curve from cycles 17 to 20.

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(2)
(Total 7 marks)

Q8. Read the following passage.

Shark-fin soup is an expensive delicacy. To provide the basic ingredient, fishermen catch the sharks, hack the fins off and throw the dead bodies back into the ocean. But sharks are slow to mature and produce only a few offspring at a time, so they are vulnerable to overfishing. Monitoring the shark-fin trade is difficult, as once a fin has been cut off, it can be extremely difficult to work out precisely from which species it was taken.

The DNA from different species of sharks shows some differences in base sequence. This has enabled a new genetic fingerprinting technique to be developed. This technique would allow conservationists and fisheries managers to assess which of the 400 shark species are most threatened by the trade in shark fins.

An identification process has been developed using a range of "primers". These are short pieces of single-stranded DNA that are complementary to a particular sequence of DNA. Each primer is specific to the DNA of one shark species.

The primers are added to DNA taken from a shark's fin and the polymerase chain reaction is carried out. Only two primers, one at each end of a certain piece of DNA, will bind. The piece of DNA between the primers is replicated by the polymerase chain reaction. The primers that bind are specific to a particular species of shark and the length of the DNA fragment replicated differs for each species. When this DNA is run in an electrophoresis gel it produces a single band, enabling the researchers to identify which species of shark is involved.

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

(a) (i) Explain why the DNA for each species of shark shows differences in base sequence (line 6).

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(2)

(ii) Each primer is specific to the DNA of one shark species (line 12).

Explain why a particular primer will only bind to the DNA of one species.

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(2)

(iii) The length of the replicated DNA fragment is different for each species.

Explain why this is important in identifying the shark species involved.

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(3)

(b) In conventional DNA fingerprinting, a series of bands is produced on the electrophoresis gel, resembling the rungs of a ladder. When the DNA in this new genetic fingerprinting technique is run in an electrophoresis gel it produces just one of these 'rungs'.

Explain the reason for the difference in the number of 'rungs' produced.

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(2)

(c) Describe the polymerase chain reaction.

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(6)
(Total 15 marks)

Q9. Research scientists can increase the nutritional value of potatoes by genetically engineering potato plants. A gene which results in increased protein production has been removed from cells of an amaranth plant and inserted into cells of a potato plant.

(a) Describe how a gene could be removed from cells of an amaranth plant and inserted into cells of a potato plant.

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(6)

(b) Describe the advantages of using vegetative propagation rather than sexual reproduction to reproduce genetically engineered potato plants.

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(3)

(c) Whole potato plants can be produced from genetically identical potato cells grown in a tissue culture. Use your knowledge of genes to suggest how different cells, such as leaf and root cells, can develop from genetically identical cells.

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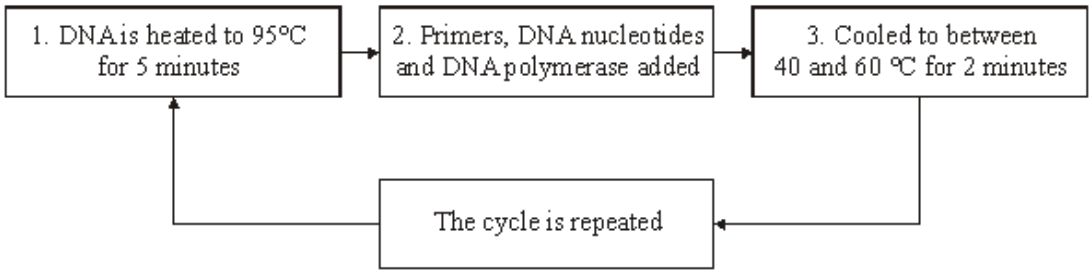
(2)

(Total 11 marks)

Q10. The polymerase chain reaction is a process which can be carried out in a laboratory to replicate DNA. The diagram shows the main stages involved in the polymerase chain reaction.



(a) Explain why DNA is heated to 95 °C.

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(1)

(b) What is the role of

(i) a primer in this process;

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(1)

(ii) DNA polymerase?

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(1)

(c) (i) How many DNA molecules will have been produced from one molecule of DNA after 6 complete cycles?

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(1)

(ii) Suggest **one** use of the polymerase chain reaction.

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(1)

(d) Give **two** ways in which the polymerase chain reaction differs from the process of transcription.

1 .....

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2 .....

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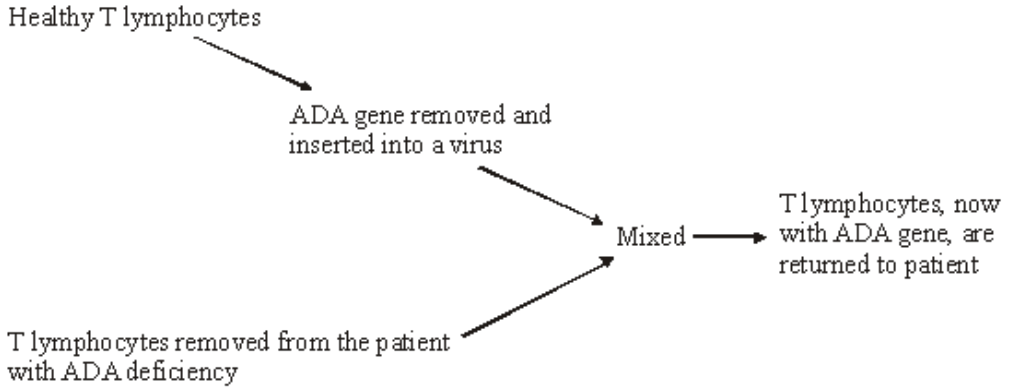
(2)
(Total 7 marks)

Q11. Gene therapy is used to treat the genetic disorder, ADA deficiency. Affected individuals are unable to produce the enzyme adenosine deaminase (ADA). Without this enzyme, T lymphocytes, a type of white blood cell, cannot provide immunity to infection. The diagram shows the processes involved in the treatment of ADA deficiency by gene therapy.



(a) What is meant by *gene therapy*?

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(1)

(b) The ADA gene is inserted into a virus. Give **two** advantages of using a virus in gene therapy.

1 .....

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2 .....

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(2)

(c) Individuals who have been treated by this method of gene therapy do not pass on the ADA gene to their children. Explain why.

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(1)

(d) T lymphocytes are produced in bone marrow. A bone marrow transplant from a genetically matched donor can provide a permanent cure for ADA deficiency.

(i) Suggest why bone marrow for a transplant is obtained from a genetically matched donor.

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(1)

(ii) Explain why treatment of ADA deficiency by gene therapy must be repeated at regular intervals, whereas a single bone marrow transplant can provide a permanent cure.

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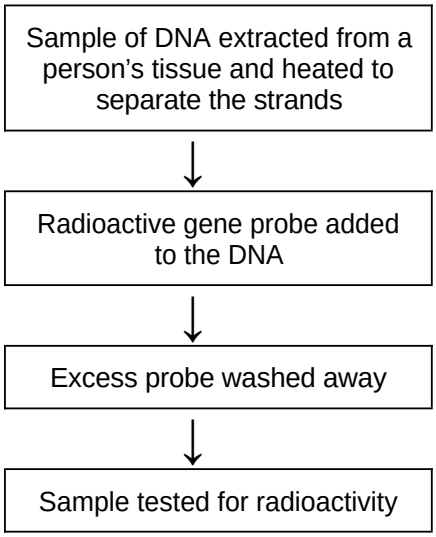
(2)

(Total 7 marks)

Q12. (a) Cystic fibrosis can be caused by any one of several mutant alleles of the cystic fibrosis gene. The most common of these mutant alleles accounts for about 70% of cases of cystic fibrosis. The use of gene probes can identify individuals carrying this allele. Gene probes are single strands of DNA which are radioactively labelled. They have a base sequence that is complementary to a mutant allele. The main stages in using a gene probe are shown in the diagram.



Using the information given, explain how the use of a gene probe could enable the presence of a mutant allele of the cystic fibrosis gene to be detected.

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(4)

(b) Sheep have been genetically engineered to produce alpha-1-antitrypsin which is used to treat cystic fibrosis. Use your knowledge of this process to explain **one** argument for and **one** against using sheep in this way.

For

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.....

Against

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(2)
(Total 6 marks)

Q13. One technique used to determine the sequence of nucleotides in a sample of DNA is the Sanger procedure. This requires four sequencing reactions to be carried out at the same time. The sequencing reactions occur in four separate tubes. Each tube contains

- a large quantity of the sample DNA
- a large quantity of the four nucleotides containing thymine, cytosine, guanine and adenine
- DNA polymerase
- radioactive primers

A modified nucleotide is also added to each tube, as shown in **Figure 1**.

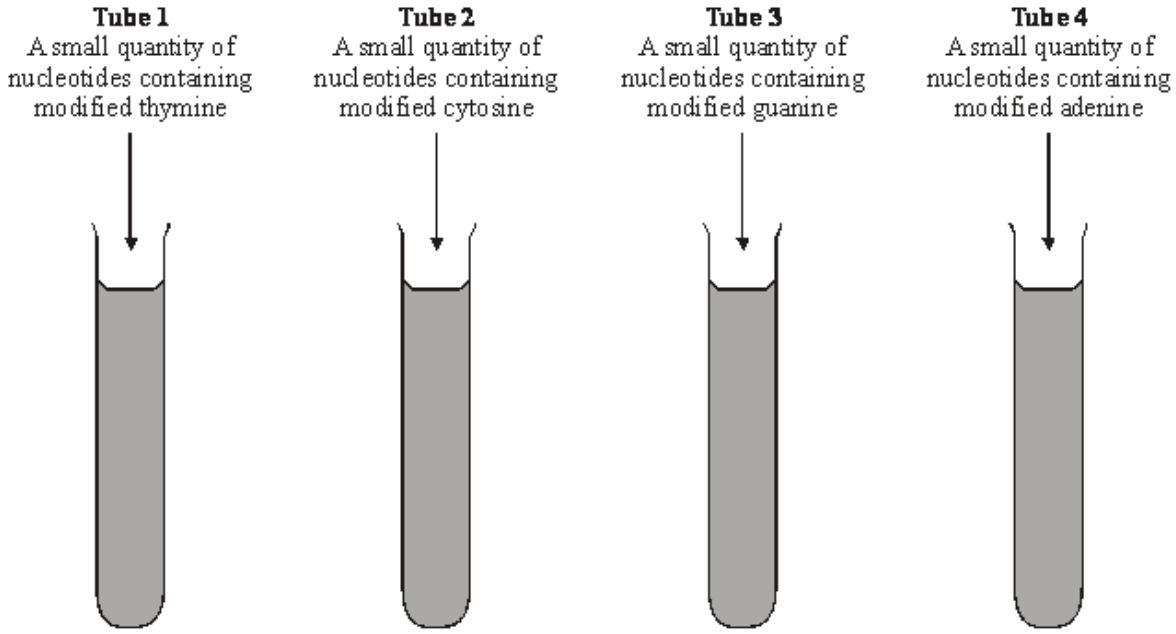

Figure 1

(a) A large quantity of the DNA sample is required for this procedure. Name the reaction used to amplify small amounts of DNA into quantities large enough for this procedure.

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(1)

(b) Explain the reason for adding each of the following to the tubes.

(i) DNA polymerase

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(1)

(ii) Primers

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(1)

(c) (i) When a modified nucleotide is used to form a complementary DNA strand, the sequencing reaction is terminated. Suggest how this sequencing reaction is terminated.

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(1)

(ii) A sample of DNA analysed by this technique had the following nucleotide base sequence.

T G G T C A C G A

Give the base sequence of the shortest DNA fragment which would be produced in **Tube 2**.

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(1)

(d) A different sample of DNA was then analysed. The DNA fragments from the four tubes were separated in a gel by electrophoresis and analysed by autoradiography. **Figure 2** shows the banding pattern produced.

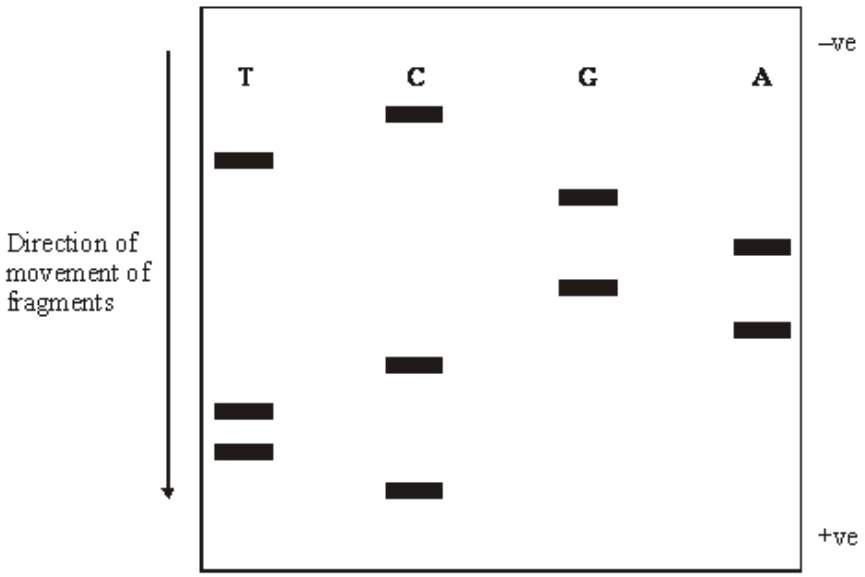

Figure 2

(i) Explain why the DNA fragments move different distances in the gel.

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(1)

(ii) What makes the DNA fragments visible on the autoradiograph?

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(1)

(iii) Use **Figure 2** to determine the sequence of nucleotides in this sample of DNA.

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(1)
(Total 8 marks)

Q14. A protein produced by a species of bacterium is toxic to caterpillars. The gene coding for this protein was removed and transferred into a crop plant.

(a) (i) Describe how the gene could have been removed from the bacterial DNA.

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(2)

(ii) Many copies of the isolated gene were required. Name the process used in a laboratory to produce many copies of DNA from a small amount.

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(1)

(b) The gene was injected into isolated cells from the crop plant. These cells were then cloned and new plants grown from the cloned cells. Explain the advantage of inserting the gene into isolated plant cells rather than directly into cells within a whole plant.

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(3)
(Total 6 marks)

Q15. (a) The polymerase chain reaction (PCR) can be used to produce large quantities of DNA.
Describe how the PCR is carried out.

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(6)

(b) About twenty percent of the DNA produced by the PCR is copied inaccurately. Suggest and explain why it is not safe to use the PCR to clone the CFTR gene for use in treating cystic fibrosis.

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(4)
(Total 10 marks)

Q16. (a) Plasmids are often used as vectors in genetic engineering.

(i) What is the role of a vector?

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(1)

(ii) Describe the role of restriction endonucleases in the formation of plasmids that contain donor DNA.

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(2)

(iii) Describe the role of DNA ligase in the production of plasmids containing donor DNA.

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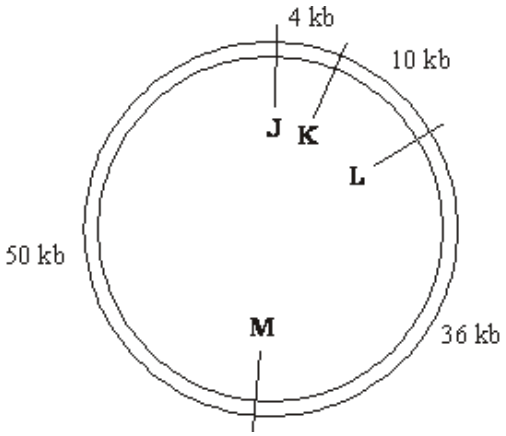
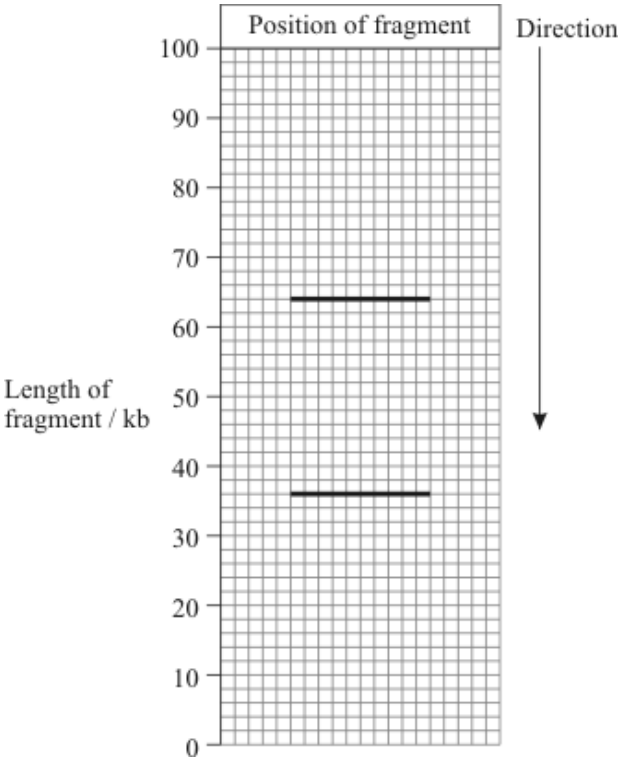
(1)

(b) There are many different restriction endonucleases. Each type cuts the DNA of a plasmid at a specific base sequence called a restriction site. The diagram shows the position of four restriction sites, **J**, **K**, **L** and **M**, for four different enzymes on a single plasmid. The distances between these sites is measured in kilobases of DNA.



1 kb = 1 kilobase

The plasmid was cut using only two restriction endonucleases. The resulting fragments were separated by gel electrophoresis. The positions of the fragments are shown in the chart below.



(i) Which of the restriction sites were cut?

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(1)

(ii) Explain your answer.

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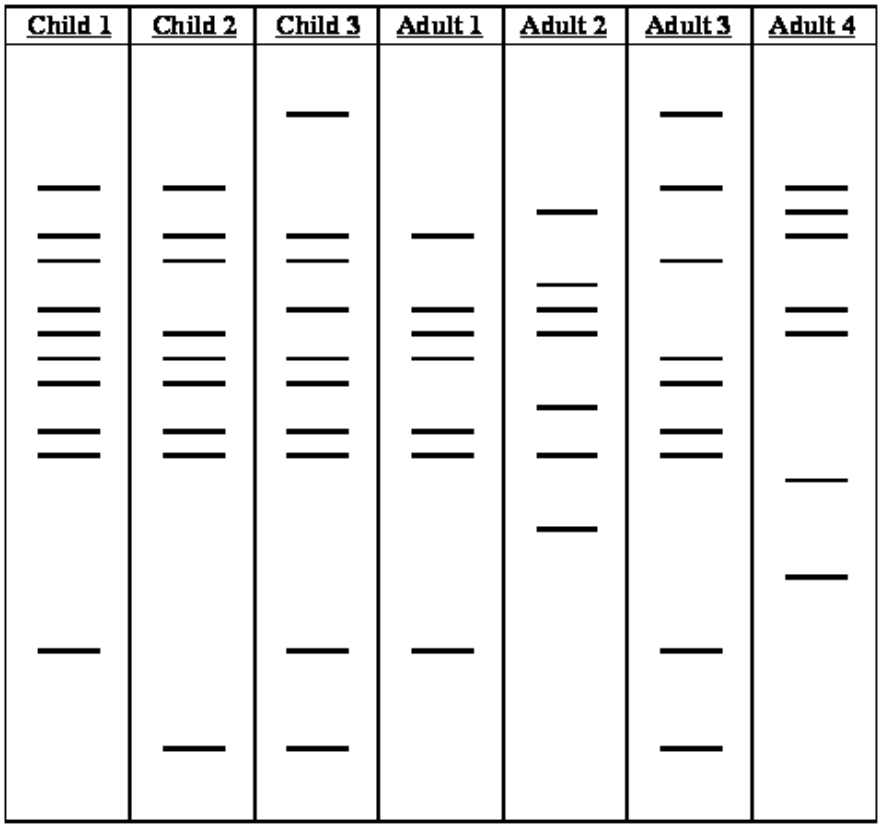
(1)

(Total 6 marks)

Q17. Read the following passage.

In 1991, nine skeletons were found in Russia. They were believed to be those of Tsar Nicholas II, his family and staff who were killed in 1917 during the Russian revolution. Very small amounts of DNA were isolated from these skeletons. This DNA was used in the polymerase chain reaction (PCR). Genetic fingerprinting was then carried out on this DNA to identify the skeletons.

The chart shows some of the results obtained from the genetic fingerprinting of seven of the skeletons, three children and four adults.



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

(a) Explain why the polymerase chain reaction was used in this investigation.

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(2)

(b) In the polymerase chain reaction, DNA is heated to 95 °C and nucleotides, enzymes and DNA primers are added to the mixture.

(i) Explain why the DNA is heated to 95 °C.

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(1)

(ii) What are DNA *primers*?

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(1)

(iii) Why are DNA primers added during the polymerase chain reaction?

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(1)

(iv) What is the advantage of the enzyme used in the polymerase chain reaction being thermostable?

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(2)

(c) Describe how genetic fingerprinting is carried out.

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(6)

(d) All three children on the chart had the same parents. One of the parents was **Adult 1**.

Which of the other three adults on the chart was the other parent? Give the reason for your answer.

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(2)
(Total 15 marks)

Q18. Read the following passage.

Malaria is a disease so deadly that it has devastated armies and destroyed great civilisations. It has been estimated that in the course of history malaria has been responsible for the death of one out of every two people who have ever lived. Even today, with all the advantages of modern technology, it is still responsible for some three million deaths a year.

The first half of the twentieth century was a time of hope for malarial control. The drugs chloroquine and proguanil had just been discovered and there seemed a real possibility of a malaria-free world. Unfortunately, this honeymoon ended almost as soon as it had started, with the emergence of drug-resistant parasite populations. Scientists now accept that whatever new drug they come up with, it is likely to have a very limited effective life. As a result, they are increasingly looking at combinations of drugs.

The approach to malaria control which holds the best hope is the production of a vaccine. One of these is being developed by a researcher in South America. His vaccine is based on a small synthetic polypeptide called SPf66 which is dissolved in a saline solution and given as an injection. A series of early trials on human volunteers produced confusing results. In one trial the effectiveness of the vaccine was claimed to be 80% while, in others, the results were statistically insignificant. Not only were the results inconclusive but the methods used were challenged by other scientists. In particular, the controls were considered inappropriate.

Another, possibly more promising, approach has been the development of a DNA-based vaccine. In theory, all that is required is to identify the DNA from the parasite which encodes key antigens. Unfortunately, scientists have hit snags. Although they have succeeded in sequencing the human genome, the genome of the malarial parasite has created major difficulties. This is partly because of the very high proportion of the bases adenine and thymine. In some places these two bases average 80%, and on chromosomes 2 and 3 nearly 100% of the bases present are adenine and thymine. Because of this, it has proved impossible to cut the relevant DNA with the commonly available restriction enzymes into pieces of a suitable size for analysis.

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

(a) Explain how a resistant parasite population is likely to arise and limit the life of any new anti-malarial drug (lines 8 - 9).

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(3)

(b) A person has a 1 in 500 probability of being infected by a chloroquine-resistant strain of malarial parasite and a 1 in 500 probability of being infected by a proguanil-resistant strain. Use a calculation from these figures to explain why scientists are “increasingly looking at combinations of drugs” (lines 9 - 10).

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(2)

(c) (i) Explain why trials of the SPf66 vaccine needed a control.

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(1)

(ii) The controls for the SPf66 vaccine trials were considered inappropriate (line 17).

Suggest how the control groups in these trials should have been treated.

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(2)

(d) In some of the DNA of a malarial parasite, the proportion of adenine and thymine bases averages 80% (lines 22 - 23). In this DNA what percentage of the nucleotides would you expect to contain

(i) phosphate; .....

(ii) guanine? .....

(2)

(e) (i) Use your knowledge of enzymes to explain why restriction enzymes only cut DNA at specific restriction sites.

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(3)

(ii) Restriction enzymes that can cut the DNA of chromosomes 2 and 3 produce pieces that are too small for analysis. Explain why these restriction enzymes produce small DNA fragments.

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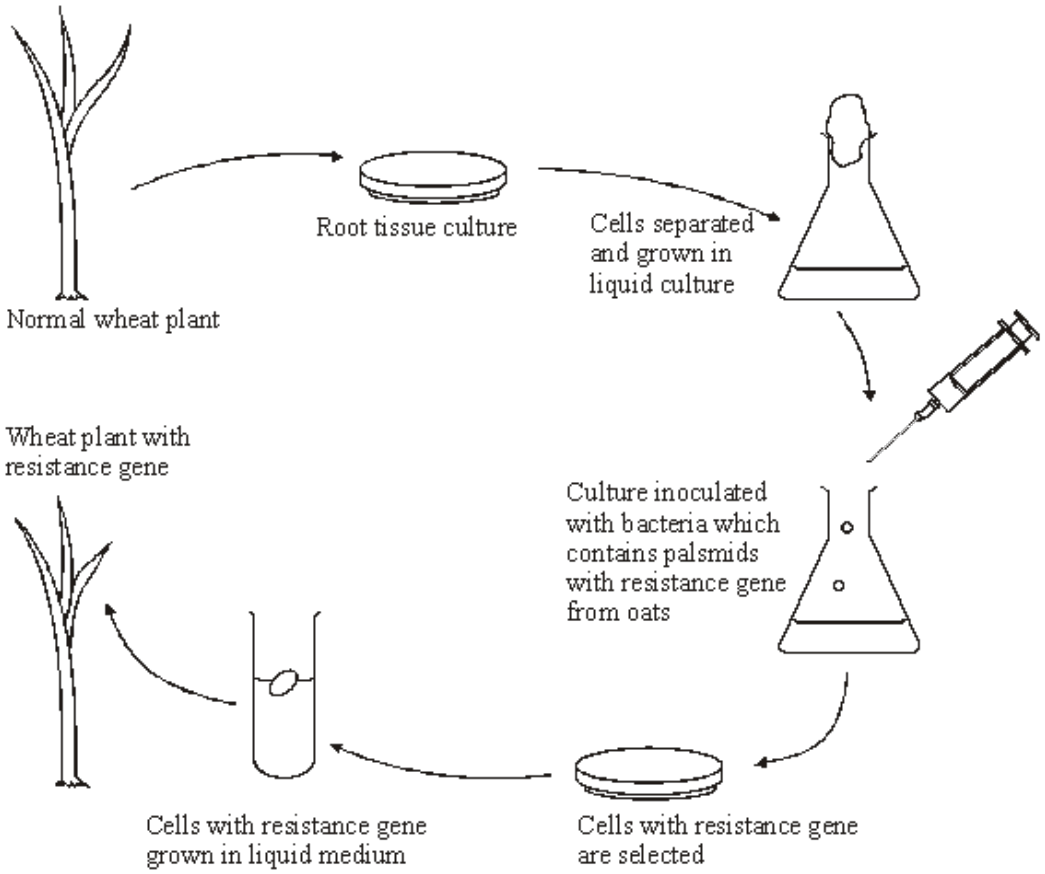
(2)

(Total 15 marks)

Q19. 'Take-all' is a disease of wheat caused by a fungus. It can cause serious damage to the crop.

There is no gene for resistance to this fungus in wheat. There is, however, a gene for resistance to this fungus present in oats.

The diagram shows how this gene might be transferred to wheat.



(a) (i) The wheat plant with the resistance gene contains recombinant DNA. What is *recombinant* DNA?

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(1)

(ii) The plasmids act as vectors for the resistance gene. What is a *vector*?

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(1)

(iii) Suggest how cells with the resistance gene might be selected.

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(2)

(b) A laboratory has oat plants containing the resistance gene and a supply of plasmids.

Describe how bacteria may be produced which have the resistance gene in their plasmids.

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(6)
(Total 10 marks)

Q20. (a) (i) Some human DNA was cut into separate pieces using a restriction enzyme which produced a staggered cut. A scientist wanted to insert these pieces of DNA into plasmids and used the same restriction enzyme to cut the plasmids. Explain why the pieces of human DNA would be able to join to the cut DNA of the plasmids.

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(2)

(ii) Which other enzyme must the scientist have added to the mixture to form recombinant plasmids?

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(1)

(b) A plasmid may be used as a vector. Explain what is meant by a *vector* in this context.

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(2)

(c) Molecular biologists often use plasmids which contain antibiotic resistance genes.

Explain the reason for this.

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(2)
(Total 7 marks)

Q21. (a) (i) Some human DNA was cut into separate pieces using a restriction enzyme which produced a staggered cut. A scientist wanted to insert these pieces of DNA into plasmids and used the same restriction enzyme to cut the plasmids. Explain why the pieces of human DNA would be able to join to the cut DNA of the plasmids.

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(2)

(ii) Which other enzyme must the scientist have added to the mixture to form recombinant plasmids?

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(1)

(b) A plasmid may be used as a vector. Explain what is meant by a *vector*.

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(2)

(c) Molecular biologists often use plasmids which contain antibiotic resistance genes.

Explain the reason for this.

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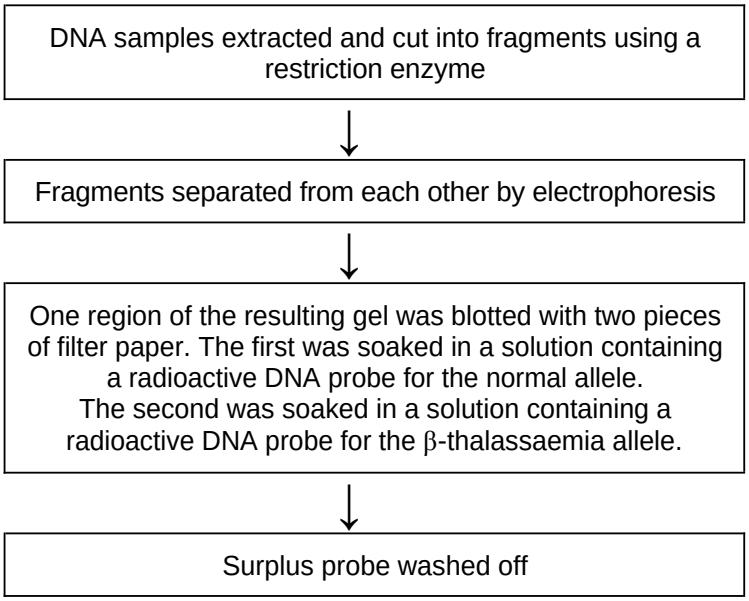
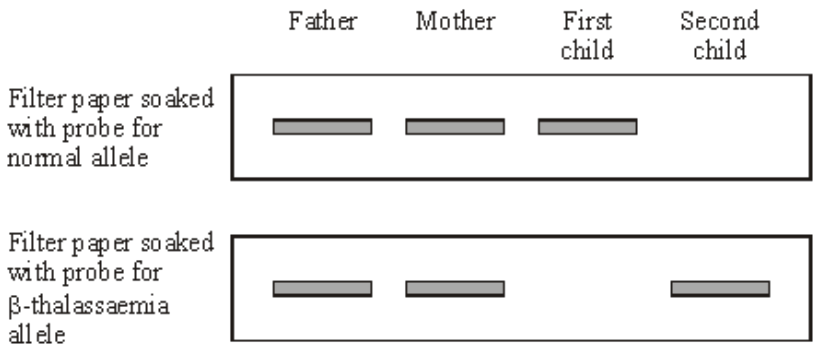
(2)
(Total 7 marks)

Q22. β-thalassaemia is a genetic condition in which abnormal haemoglobin is produced. In one form, the recessive allele for β-thalassaemia, **t**, differs from the normal allele, **T**, by a single base-pair. A radioactive DNA probe was used to investigate the genotypes of four members of one family. The flowchart summarises the technique involved.



The diagram below shows the appearance of the two pieces of filter paper which resulted from the investigation.



(a) What is the probability that the next child that this couple have is a girl who has β-thalassaemia? Explain your answer.

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(3)

(b) (i) The fragment of DNA containing the normal allele and the fragment with the β-thalassaemia allele moved the same distance on the gel. Explain why.

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(2)

(ii) The allele for β-thalassaemia differs from the normal allele by only one base-pair. Explain why the probe used to identify these alleles consists of a piece of DNA twenty bases in length and not just one base.

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(2)
(Total 7 marks)

Q23. A gene was broken into fragments using enzyme **Z**. The mixture of fragments produced was then separated by electrophoresis.

(a) What type of enzyme is enzyme **Z**?

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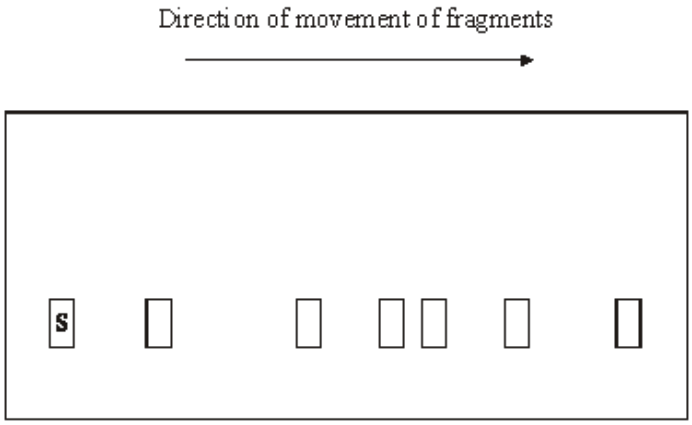
(1)

The table shows the number of base pairs present in the fragments.

Fragment	Number of base pairs ($\times 10^3$)
1	4.65
2	5.72
3	10.71
4	2.39
5	5.35
6	7.53

The diagram shows the electrophoresis gel used. The mixture of fragments was placed at the start point marked **S** and the process started. The boxes indicate the positions reached by the different fragments.



(b) Explain why base pairs are a suitable way of measuring the length of a piece of DNA.

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(2)

(c) (i) Write **6** above the appropriate box on the diagram to show the position you would expect fragment **6** to have reached.

(1)

(ii) Explain how you arrived at your answer.

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(1)

(d) Enzyme **Z** recognises a particular sequence of bases in the gene. How many times does this sequence appear in the DNA of this gene?

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(1)
(Total 6 marks)

Q24. Scientists are working to produce a genetically modified bacterium to treat patients suffering from a disease of the digestive system. They plan to collect mRNA from human cells. This will be used to produce the DNA of the gene for the protein interleukin. They will then transfer this human gene into the bacterium *Lactococcus*. The scientists intend patients to swallow the genetically modified bacteria. These bacteria will release interleukin inside the digestive system to treat the disease.

(a) (i) Name the type of enzyme which will be used to produce the DNA from the mRNA.

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(1)

(ii) It is easier to obtain the interleukin gene from mRNA rather than directly from the DNA removed from human cells. Explain why.

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(1)

(b) The scientists propose to put the gene directly into the DNA of *Lactococcus*. Describe the role of the enzyme ligase in this process.

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(1)
(Total 3 marks)

Q25. Essay

You should write your essay in continuous prose.

Your essay will be marked for its scientific accuracy.

It will also be marked for your selection of relevant material from different parts of the specification and for the quality of your written communication.

The maximum number of marks that can be awarded is

Scientific	16
Breadth of knowledge	3
Relevance	3
Quality of written communication	3

Write an essay on the following topic:

Bacteria affect the lives of humans and other organisms in many ways. Apart from causing disease, describe how bacteria may affect the lives of humans and other organisms.

(Total 25 marks)

Q26. Read the following passage.

DNA tests were used to confirm the identity of deposed Iraqi leader Saddam Hussein, after his capture in December 2003. DNA tests were carried out to prove the suspect was not one of the many alleged “look alikes” of the former leader.

Firstly, the DNA was extracted from the mouth of the captured man using a swab. Great care was taken to check that the swab did not become contaminated with any other DNA. DNA extracted from the swab was then subjected to a standard technique called the polymerase chain reaction (PCR), which takes a couple of hours. Lastly, the sample was “typed” to give the genetic fingerprint. This was produced within 24 hours of Saddam Hussein’s capture. Tests for use in criminal cases often take much longer because samples are very small or contaminated.

It appears that Hussein’s genetic fingerprint was already stored away for comparison. This was obtained from personal items such as his toothbrush. DNA from the toothbrush would have been subjected to PCR before a DNA fingerprint could have been obtained.

Source: adapted from SHAONI BHATTACHARYA, *New Scientist* 15 December, 2003

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

(a) Describe how the technique of genetic fingerprinting is carried out and explain how it can be used to identify a person, such as Saddam Hussein.

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(6)

(b) Explain how DNA could be present on a toothbrush (line 12).

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(2)

(c) (i) Explain why the polymerase chain reaction was used on the sample of DNA from the toothbrush (lines 12-13).

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(2)

(ii) Explain **one** way in which the polymerase chain reaction differs from DNA replication in a cell.

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(2)

(d) Tests for use in criminal cases often take much longer because samples are very small or contaminated (lines 8-10). Explain why it takes longer to obtain a genetic fingerprint if the sample is

(i) very small;

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(1)

(ii) contaminated.

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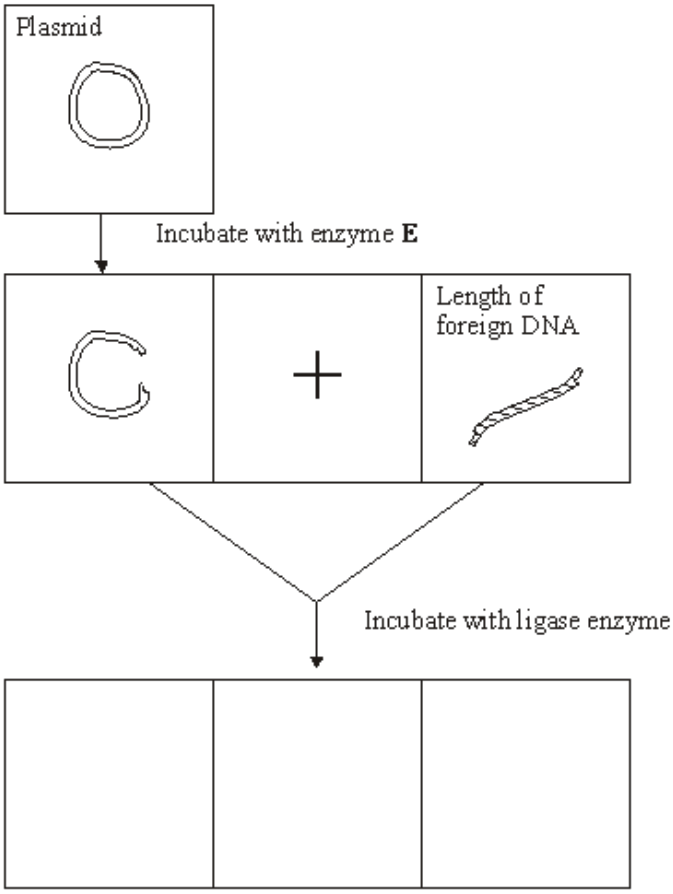
(2)
(Total 15 marks)

Q27. Plasmids can be used as vectors to insert lengths of foreign DNA into bacteria. The diagram shows how this is achieved.



(a) Name enzyme **E**.

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(1)

(b) Cut plasmids and lengths of foreign DNA can join. What features of their ends allows them to join?

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(2)

(c) Draw **three** different structures that could be formed by incubating cut plasmids and lengths of foreign DNA with ligase. Use the spaces provided on the diagram.

(3)
(Total 6 marks)

Q28. Restriction enzymes are used in DNA technology. They digest DNA at specific recognition sequences on the DNA molecule.

(a) **Figure 1** shows the recognition sequence of a restriction enzyme called *Eco*RI.

Figure 1

--G-A-A-T-T-C--
--C-T-T-A-A-G—

(i) Name the type of reaction that occurs when *Eco*RI digests DNA.

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(1)

(ii) Explain why *Eco*RI digests DNA only at the specific recognition sequence shown in **Figure 1**.

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(1)

(iii) The recognition sequence shown is referred to as a 6 bp palindromic sequence. Use evidence from **Figure 1** to explain what this means.

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(1)

(b) The piece of DNA shown in **Figure 2** was labelled using a radioactive nucleotide. The piece of DNA is 10 kilobases long.

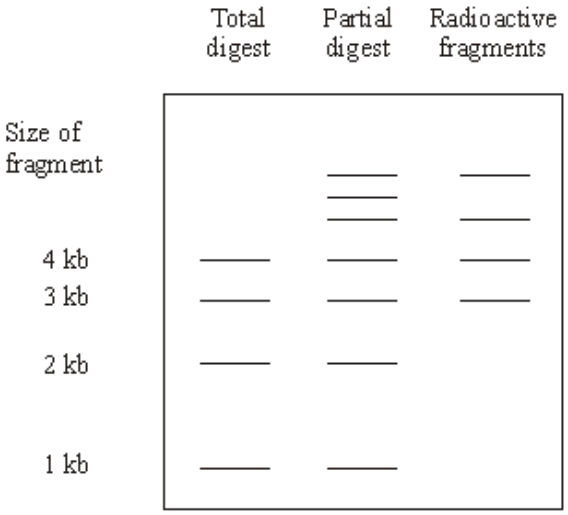
Figure 2

This piece of DNA was then digested using *Eco*RI and the resulting fragments of DNA were separated using electrophoresis.

Figure 3 shows the results of elecrophoresis. The three lanes of the electrophoresis gel show:

- the fragments of DNA formed after total digestion of the piece of DNA
- the fragments of DNA formed after partial digestion of the piece of DNA
- those fragments after partial digestion that contained radioactivity.

Figure 3



(i) The total digestion lane shows four fragments. How many times did the recognition sequence for *Eco*RI appear in the piece of DNA?

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(1)

(ii) Explain the presence of the three additional fragments in the partial digestion lane.

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(2)

(iii) The evidence from **Figure 3** was used to construct a restriction map of the piece of DNA. The map is shown in **Figure 4**

Figure 4

Explain why it is possible to map the positions of

the 3kb fragment

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the 1 kb fragment

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(2)
(Total 8 marks)

Q29. (a) What is a gene probe?

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(3)

(b) Give **two** ways in which the information obtained from the use of gene probes might be helpful to a doctor who is counselling someone with a family history of cancer.

1 .....

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2 .....

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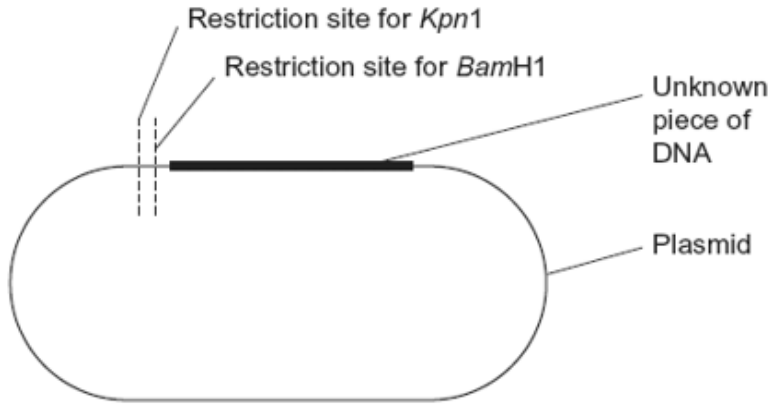
(2)
(Total 5 marks)

Q30. Scientists used restriction mapping to investigate some aspects of the base sequence of an unknown piece of DNA. This piece of DNA was 3 000 base pairs (bp) long.

The scientists took plasmids that had one restriction site for the enzyme *Kpn*1 and one restriction site for the enzyme *Bam*H1. They inserted copies of the unknown piece of DNA into the plasmids. This produced recombinant plasmids.

The diagram shows a recombinant plasmid.



(a) When the scientists digested one of the recombinant plasmids with *Kpn*1, they obtained two fragments. One fragment was measured as 1 000 bp.
The other fragment was described as "very large".

(i) What does this show about the base sequence of the unknown piece of DNA?

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(2)

(ii) One of the fragments that the scientists obtained was described as "very large". What is represented by this very large fragment?

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(1)

(b) When the scientists digested another of the recombinant plasmids with *Bam*H1, they obtained three fragments.

How many *Bam*H1 restriction sites are there in the unknown piece of DNA?

(1)

(c) (i) Scientists can separate fragments of DNA using electrophoresis. Suggest how they can use electrophoresis to estimate the number of base pairs in the separated fragments.

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(2)

(ii) Scientists need to take precautions when they carry out restriction mapping. They need to make sure that the enzyme they have used has completely digested the DNA. One check they may carry out is to add the sizes of the fragments together. How could scientists use this information to show that the DNA has **not** been completely digested? Explain your answer.

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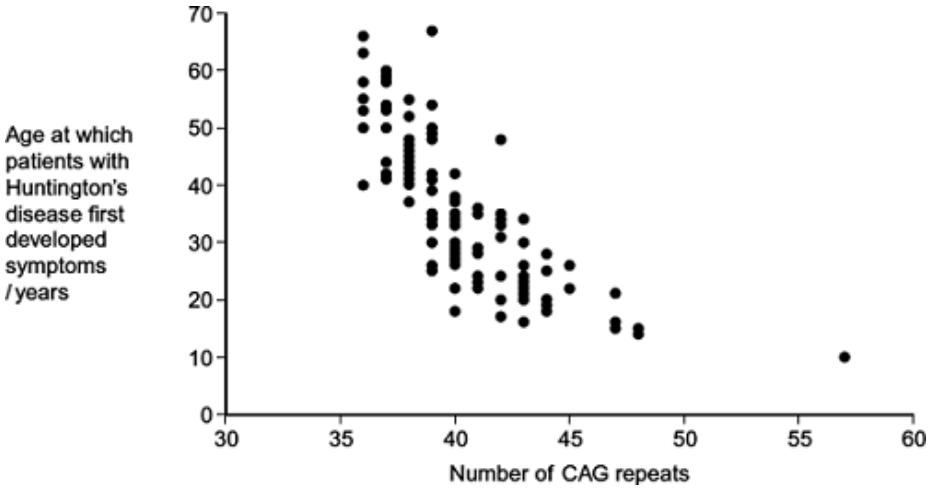
(2)

(Total 8 marks)

Q31. Huntington's disease is a genetic condition that leads to a loss in brain function. The gene involved contains a section of DNA with many repeats of the base sequence CAG. The number of these repeats determines whether or not an allele of this gene will cause Huntington's disease.

- An allele with 40 or more CAG repeats will cause Huntington's disease.
- An allele with 36 – 39 CAG repeats may cause Huntington's disease.
- An allele with fewer than 36 CAG repeats will not cause Huntington's disease.

The graph shows the age at which a sample of patients with Huntington's disease first developed symptoms and the number of CAG repeats in the allele causing Huntington's disease in each patient.



(a) (i) People can be tested to see whether they have an allele for this gene with more than 36 CAG repeats. Some doctors suggest that the results can be used to predict the age at which someone will develop Huntington's disease.

Use information in the graph to evaluate this suggestion.

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(Extra space) .....

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(3)

(ii) Huntington's disease is always fatal. Despite this, the allele is passed on in human populations. Use information in the graph to suggest why.

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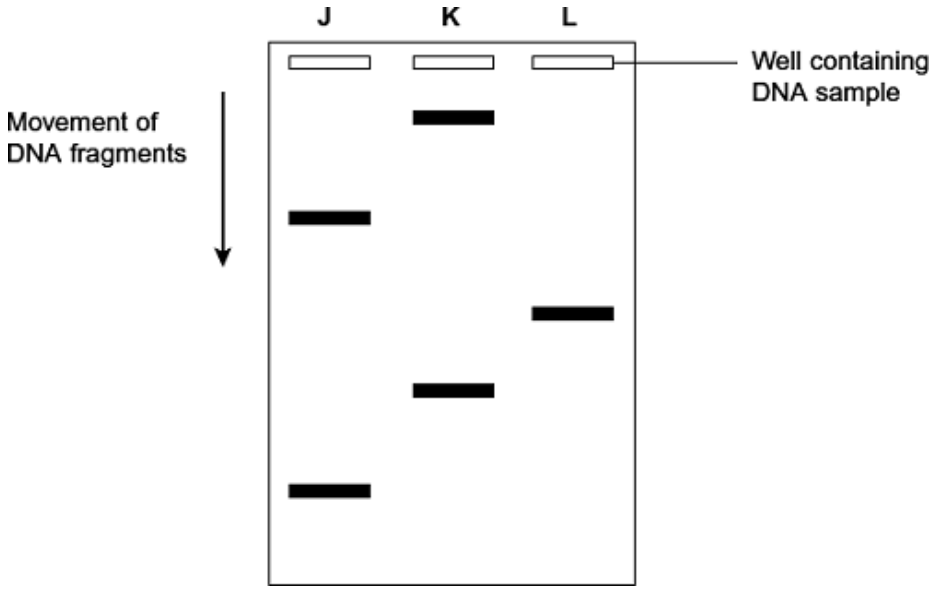
(2)

(b) Scientists took DNA samples from three people, **J**, **K** and **L**. They used the polymerase chain reaction (PCR) to produce many copies of the piece of DNA containing the CAG repeats obtained from each person. They separated the DNA fragments by gel electrophoresis. A radioactively labelled probe was then used to detect the fragments. The diagram shows the appearance of part of the gel after an X-ray was taken. The bands show the DNA fragments that contain the CAG repeats.



(i) Only one of these people tested positive for Huntington's disease. Which person was this? Explain your answer.

Person .....

Explanation .....

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(2)

(ii) The diagram only shows part of the gel. Suggest how the scientists found the number of CAG repeats in the bands shown on the gel.

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(1)

(iii) Two bands are usually seen for each person tested. Suggest why only one band was seen for Person **L**.

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(1)
(Total 9 marks)

Q32. (a) Adrenaline binds to receptors in the plasma membranes of liver cells. Explain how this causes the blood glucose concentration to increase.

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(Extra space) .....

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(2)

(b) Scientists made an artificial gene which codes for insulin. They put the gene into a virus which was then injected into rats with type I diabetes. The virus was harmless to the rats but carried the gene into the cells of the rats.

The treated rats produced insulin for up to 8 months and showed no side-effects. The scientists measured the blood glucose concentrations of the rats at regular intervals. While the rats were producing the insulin, their blood glucose concentrations were normal.

(i) The rats were not fed for at least 6 hours before their blood glucose concentration was measured. Explain why.

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(1)

(ii) The rats used in the investigation had type I diabetes. This form of gene therapy may be less effective in treating rats that have type II diabetes. Explain why.

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(1)

(iii) Research workers have suggested that treating diabetes in humans by this method of gene therapy would be better than injecting insulin. Evaluate this suggestion.

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(Extra space) .....

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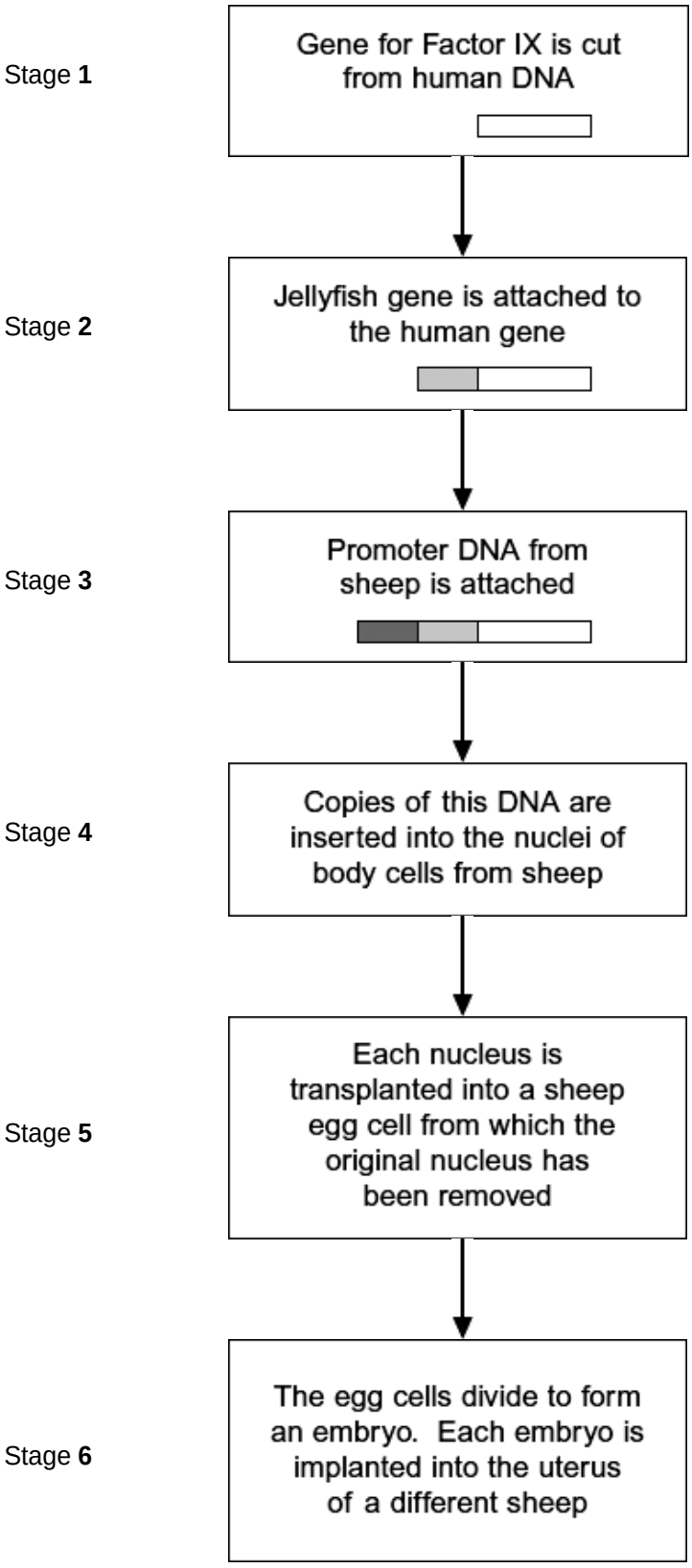
(4)

(Total 8 marks)

Q33. Haemophilia is a genetic condition in which blood fails to clot. Factor IX is a protein used to treat haemophilia. Sheep can be genetically engineered to produce Factor IX in the milk produced by their mammary glands. The diagram shows the stages involved in this process.



(a) Name the type of enzyme that is used to cut the gene for Factor IX from human DNA (Stage **1**) .

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(1)

(b) (i) The jellyfish gene attached to the human Factor IX gene (Stage **2**) codes for a protein that glows green under fluorescent light. Explain the purpose of attaching this gene.

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(2)

(ii) The promoter DNA from sheep (Stage **3**) causes transcription of genes coding for proteins found in sheep milk.

Suggest the advantage of using this promoter DNA.

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(Extra space) .....

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(2)

(c) Many attempts to produce transgenic animals have failed. Very few live births result from the many embryos that are implanted.

(i) Suggest **one** reason why very few live births result from the many embryos that are implanted.

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(Extra space) .....

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(2)

(ii) It is important that scientists still report the results from failed attempts to produce transgenic animals. Explain why.

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(2)
(Total 9 marks)