A-Level Biology

Gene Technologies

Question Paper

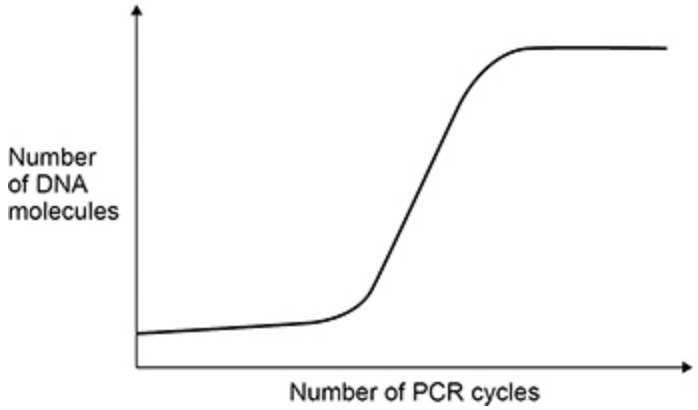
Time available: 74 minutes
Marks available: 53 marks

www.accesstuition.com

1. (a) Describe and explain how the polymerase chain reaction (PCR) is used to amplify a DNA fragment.

(4)

The figure below shows the number of DNA molecules produced using a PCR.



(b) Explain the shape of the curve in the figure above.

(2)

(Total 6 marks)

2. Plants transport sucrose from leaves to other tissues for growth and storage. SUT1 is a sucrose co-transporter protein.

Scientists investigated whether the cells of tobacco plant leaves used SUT1 to transport sucrose to other tissues.

(a) The scientists used a radioactively labelled DNA probe to show that the cells of tobacco plant leaves contained the *SUT1* gene.

Describe how they would do this.

Do **not** include PCR in your answer.

(4)

(b) To study the role of SUT1 in tobacco plants, scientists reduced the expression of the *SUT1* gene.

When the *SUT1* gene is transcribed, the SUT1 mRNA produced is called 'sense' SUT1 mRNA. The scientists genetically modified plants by inserting an **extra** gene so that this **also** allowed the production of 'antisense' SUT1 mRNA.

The scientists had two types of tobacco plants:

- type **A** – plants that were genetically modified
- type **B** – plants that were **not** genetically modified.

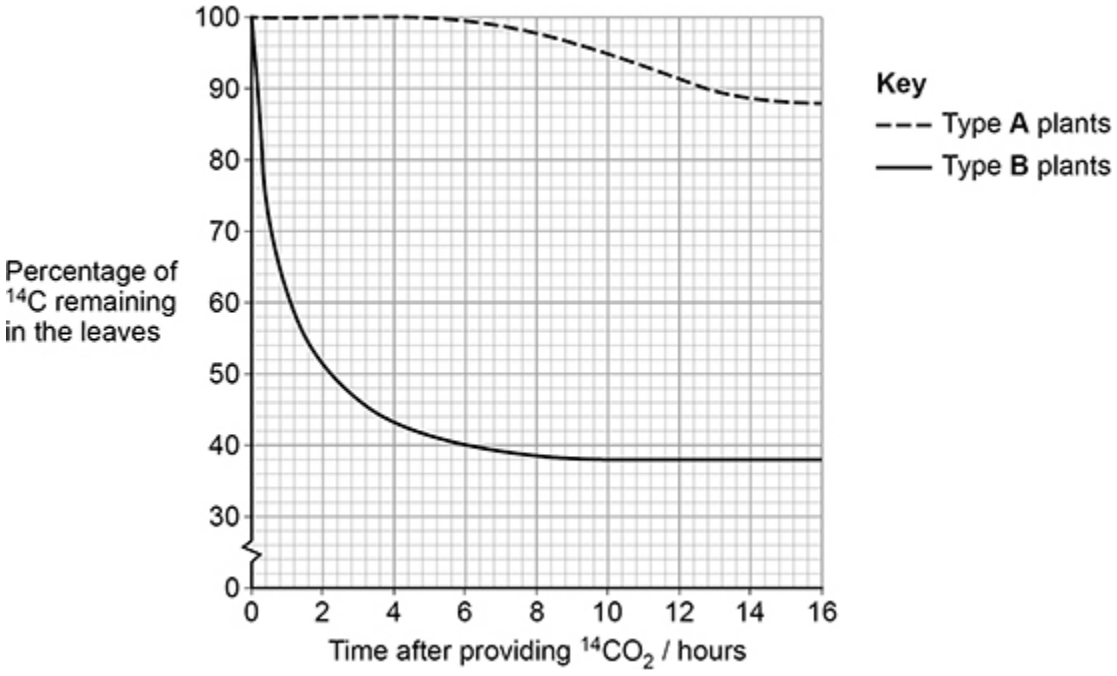
Suggest how the production of 'antisense' SUT1 mRNA in type **A** plants would reduce the expression of the *SUT1* gene.

(4)

(c) The scientists hypothesised that lower rates of sucrose transport from leaves would cause reduced growth.

To test this hypothesis, the scientists provided leaves of type **A** and type **B** plants with labelled carbon dioxide ($^{14}CO_2$). To estimate sucrose transport out of leaves, they measured the percentage of ^{14}C remaining in the leaves for 16 hours.

The figure below shows their results.



Calculate the ratio of percentage of ^{14}C remaining in leaves of type **B** to type **A** plants 16 hours after providing $^{14}CO_2$

Answer _____

(1)

(d) In type **B** plants, the percentage of ^{14}C remaining in the leaves does not reach zero per cent, as shown in the figure above.

Suggest **two** reasons why.

1 _____

_____

2 _____

_____

(2)

The scientists measured physiological differences between type **A** plants and type **B** plants.

The table below shows the scientists' results as they presented them.

Physiological factor	**Type of tobacco plant**	
	Type A	**Type B**
Rate of sucrose transport from leaf cells / µmol m^{-2} s^{-1}	0.1	3.7
Leaf sucrose concentration / mmol m^{-2}	22	4
Ratio of shoot:root dry mass	6:1	2:1
Rate of photosynthesis / µmol glucose m^{-2} s^{-1}	4	14

Sucrose is able to inhibit the production and activity of rubisco in leaves of a plant. Type **A** plants have decreased dry mass compared with type **B** plants.

(e) Use all the information to suggest **and** explain how the physiological factors in the table above would contribute to the decreased dry mass observed in type **A** plants.

(4)

(Total 15 marks)

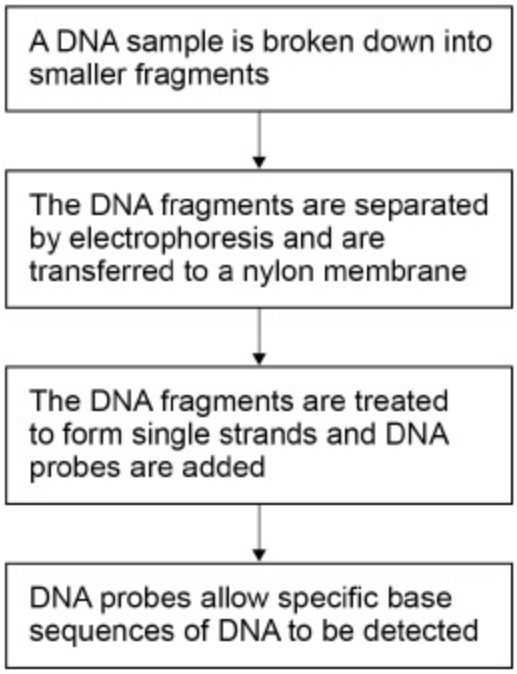
3. (a) What is a DNA probe?

(2)

DNA probes are used to detect specific base sequences of DNA.

The process is shown in **Figure 1**.

Figure 1



(b) Describe how the DNA is broken down into smaller fragments.

_____

_____

_____

_____

_____

_____

(2)

(c) The DNA on the nylon membrane is treated to form single strands. Explain why.

_____

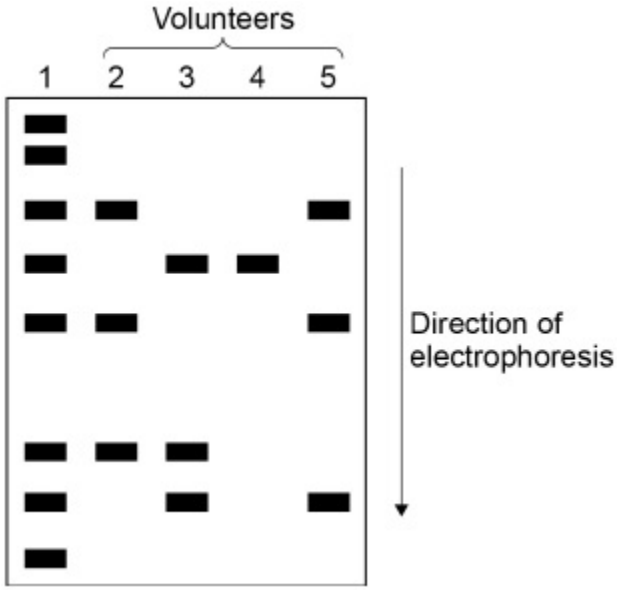
_____

(1)

A scientist used DNA probes and electrophoresis to screen four volunteers for five different viral DNA fragments.

Figure 2 shows the results the scientist obtained. The lanes numbered 2 to 5 represent the four volunteers.

Figure 2



(d) Lane 1 of **Figure 2** enabled the size of the different viral fragments to be determined.

Suggest and explain how.

_____

_____

_____

_____

_____

_____

(2)

The lengths of the viral DNA fragments were:

- 600 base pairs
- 250 base pairs
- 535 base pairs
- 300 base pairs
- 500 base pairs.

(e) Which volunteers had at least one of the viral DNA fragments with 250 base pairs or 535 base pairs?

_____

(1)

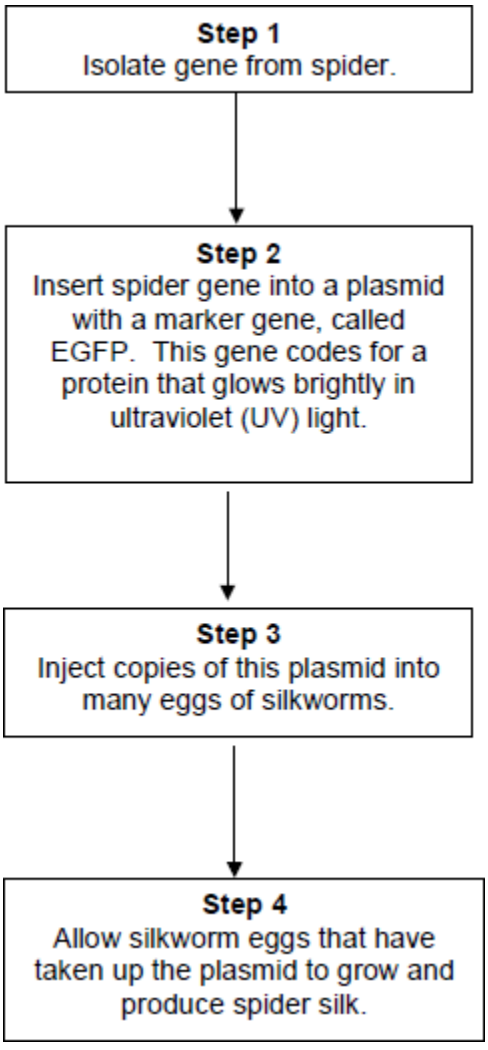
(Total 8 marks)

4. Silkworms secrete silk fibres, which are harvested and used to manufacture silk fabric.

Scientists have produced genetically modified (GM) silkworms that contain a gene from a spider.

The GM silkworms secrete fibres made of spider web protein (spider silk), which is stronger than normal silk fibre protein.

The method the scientists used is shown in the figure below.



(a) Suggest why the plasmids were injected into the eggs of silkworms, rather than into the silkworms.

_____

_____

_____

_____

(2)

(b) Suggest why the scientists used a marker gene and why they used the EGFP gene.

_____

_____

_____

_____

(2)

The scientists ensured the spider gene was expressed only in cells within the silk glands.

(c) What would the scientists have inserted into the plasmid along with the spider gene to ensure that the spider gene was only expressed in the silk glands of the silkworms?

_____

(1)

(d) Suggest **two** reasons why it was important that the spider gene was expressed only in the silk glands of the silkworms.

1. _____

_____

2. _____

_____

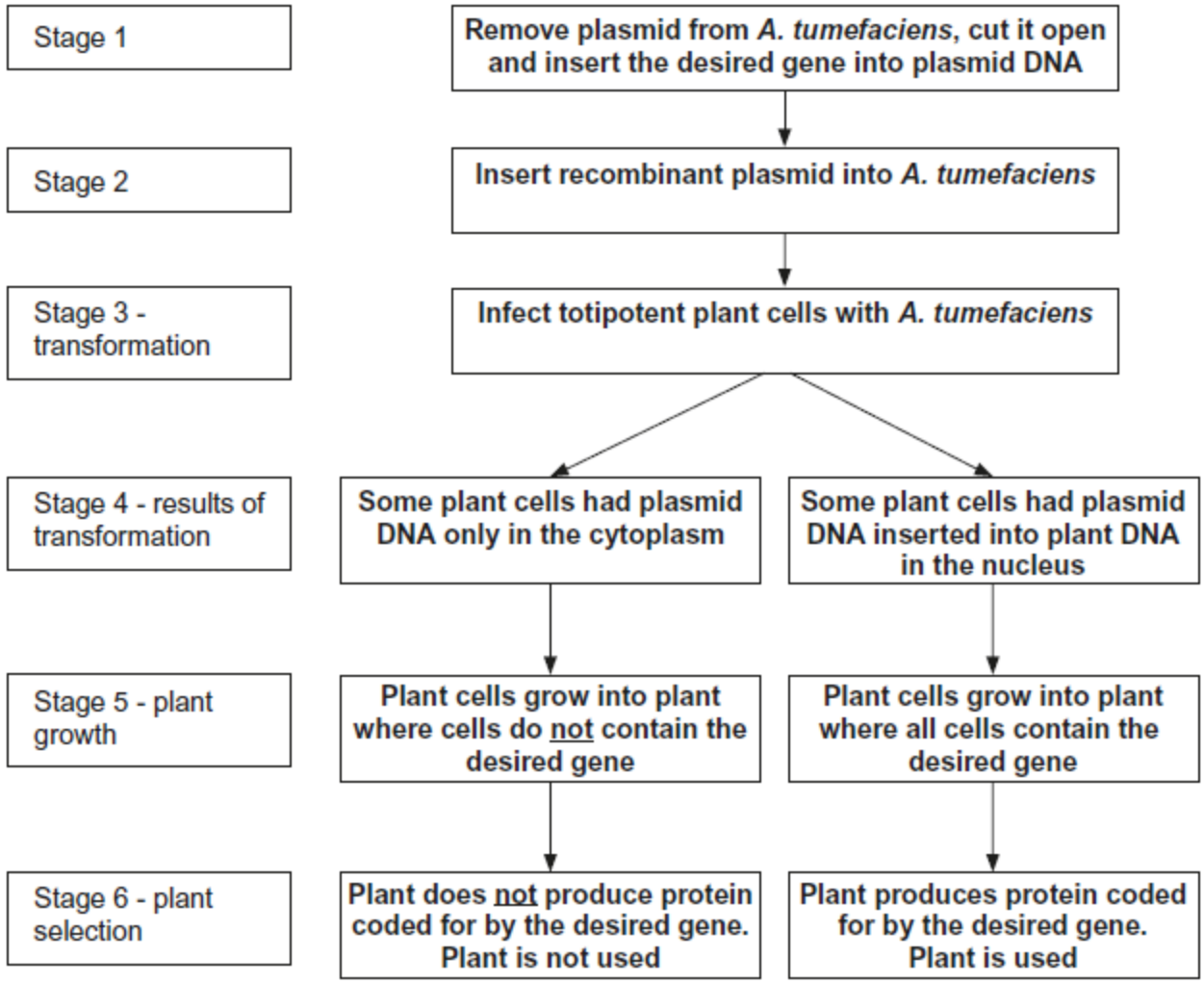
(2)

(Total 7 marks)

5. *Agrobacterium tumefaciens* is a bacterium that is often used in recombinant DNA technology to produce transformed plants that benefit humans.

A. tumefaciens contains a plasmid which can be used as a vector to transfer a desired gene into plant cells. These plant cells may then develop into plants which produce the protein coded for by the desired gene.

The diagram outlines this process.



(a) (i) In stage 1, an enzyme is used to cut open the plasmid.
Name the type of enzyme used to cut open the plasmid.

_____

(1)

(ii) In stage 1, another enzyme is used to insert the desired gene into the plasmid DNA.
Name the type of enzyme used to insert the gene into the plasmid.

_____

(1)

(b) In stage 4, some plant cells had plasmid DNA only in their cytoplasm. In other plant cells, the plasmid DNA had become inserted into plant DNA in the nucleus.

In stage 5, only cells with plasmid DNA inserted into the plant DNA in the nucleus grew into plants where all the cells contained the desired gene.

Explain why some of the plants in stage 5 contained the desired gene in all of their cells and others did not.

(3)

(c) The **desired gene** in the diagram was from an insect. In stage 6, the plant containing this gene was able to use it to synthesise an insect protein.

The plant is able to synthesise the insect protein. Explain why this is possible.

(3)

(Total 8 marks)

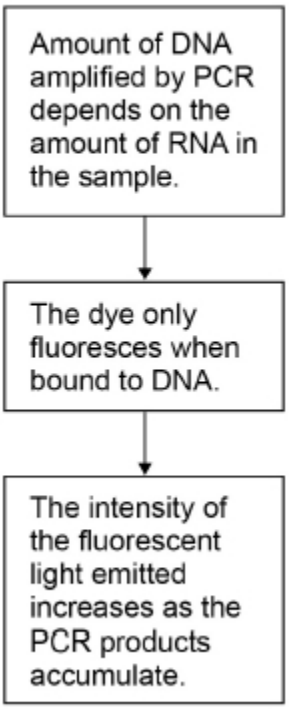
6. One way to detect and measure accurately the amount of RNA in a tissue sample is by RT-PCR (reverse transcriptase-polymerase chain reaction).

RT-PCR uses a reaction mixture containing:

- the sample for testing
- reverse transcriptase
- DNA nucleotides
- primers
- DNA polymerase
- fluorescent dye.

The principle behind this method is shown in **Figure 1**.

Figure 1



(a) Explain the role of reverse transcriptase in RT-PCR.

_____

_____

_____

(1)

(b) Explain the role of DNA polymerase in RT-PCR.

(1)

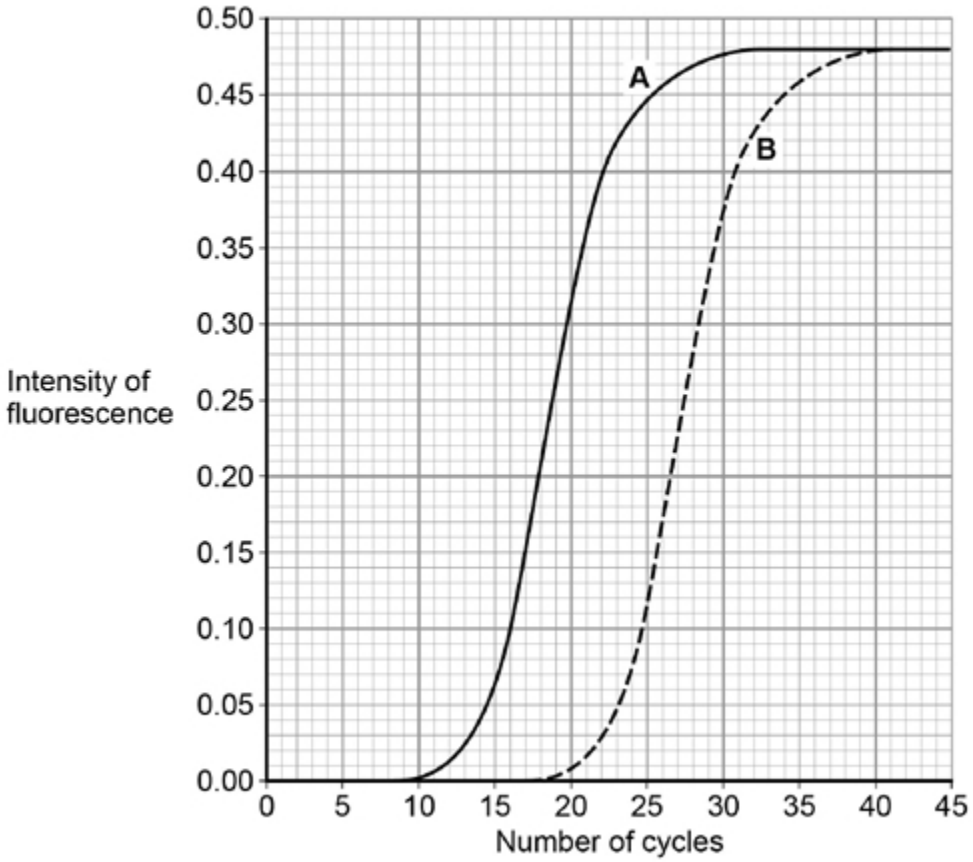
(c) Any DNA in the sample is hydrolysed by enzymes before the sample is added to the reaction mixture.

Explain why.

(2)

(d) **Figure 2** shows the results from using RT-PCR to detect RNA in two different samples, **A** and **B**.

Figure 2



A quantitative comparison can be made of the amount of RNA in samples **A** and **B**. This involves determining the number of cycles required to reach 50% maximum concentration of DNA (**C**).

The amount of RNA in a sample can be measured as: $\frac{1}{C}$

Use this information to calculate the ratio for RNA content in sample **A** : RNA content in sample **B**.

Answer _____

(2)

(e) Suggest **one** reason why DNA replication stops in the polymerase chain reaction.

_____

_____

_____

(1)

(f) Scientists have used the RT-PCR method to detect the presence of different RNA viruses in patients suffering from respiratory diseases.

The scientists produced a variety of primers for this procedure.

Explain why.

_____

_____

_____

_____

_____

(2)

(Total 9 marks)