QBT LTD.
QUANTUM BRAIN TUTORING LTD.
"TURNING BRAINS QUANTUM"

AQA A2 Biology Answer Sheet – Biotechnology and Genetic Engineering - Recombinant DNA Technology

Model Answers and Mark Schemes | Total Marks: 54

Question 1 (1 mark)

> *Define the term recombinant DNA.*

MODEL ANSWER

DNA formed by combining genetic material from two different species/sources.

MARK SCHEME

- ✓ DNA formed by combining genetic material from two different species/sources. [1 mark]

Question 2 (2 marks)

> *Explain the role of a vector in gene technology.*

MODEL ANSWER

A vector is a DNA molecule used to carry foreign genetic material into another cell. It allows the desired gene to be replicated and expressed within the host organism.

MARK SCHEME

- ✓ Carries foreign genetic material/gene of interest into a host cell. [1 mark]
- ✓ Enables replication/expression of the gene within the host cell. [1 mark]

Question 3 (3 marks)

> *Describe the function of restriction endonucleases in creating recombinant DNA.*

MODEL ANSWER

Restriction endonucleases are enzymes that cut DNA at specific recognition sequences/base sequences. They are used to cut out the desired gene from the donor organism and to cut open the plasmid/vector DNA, creating complementary sticky ends.

MARK SCHEME

- ✓ Enzymes that cut DNA. [1 mark]
- ✓ At specific recognition sequences/base sequences. [1 mark]
- ✓ To cut out the desired gene and open the vector/plasmid. [1 mark]

Question 4 (4 marks)

> *Explain why 'sticky ends' are advantageous in the formation of recombinant DNA.*

MODEL ANSWER

Sticky ends are short, single-stranded overhangs of DNA. They are advantageous because they are complementary to each other, meaning they can form hydrogen bonds with other DNA fragments cut by the same restriction enzyme. This allows the desired gene to be inserted into the vector DNA in the correct orientation, facilitating the action of DNA ligase to form phosphodiester bonds and create recombinant DNA.

MARK SCHEME

- ✓ Sticky ends are single-stranded overhangs of DNA. [1 mark]
- ✓ They are complementary to each other (if cut by the same restriction enzyme). [1 mark]
- ✓ Allow the desired gene to anneal/base pair with the vector DNA. [1 mark]
- ✓ Facilitates the insertion of the gene into the vector/action of DNA ligase. [1 mark]

Question 5 (5 marks)

> *A student is attempting to insert a human gene for insulin production into a bacterial plasmid. Outline the key steps involved in this process, starting from the isolated human gene and bacterial plasmid.*

M O D E L A N S W E R

1. The human insulin gene and the bacterial plasmid are cut with the same restriction endonuclease.
2. This creates complementary sticky ends on both the gene and the plasmid.
3. The cut human insulin gene is mixed with the cut bacterial plasmid.
4. The sticky ends anneal/base pair due to complementary bases.
5. DNA ligase is added to form phosphodiester bonds, sealing the gene into the plasmid to create recombinant DNA.

M A R K S C H E M E

- ✓ Cut human gene and plasmid with the same restriction endonuclease. [1 mark]
- ✓ To produce complementary sticky ends. [1 mark]
- ✓ Mix gene and plasmid, allowing sticky ends to anneal/base pair. [1 mark]
- ✓ Add DNA ligase. [1 mark]
- ✓ To form phosphodiester bonds, creating recombinant DNA. [1 mark]

Question 6 (2 marks)

> *State two features of plasmids that make them suitable as vectors in genetic engineering.*

M O D E L A N S W E R

1. They are small, circular DNA molecules, making them easy to manipulate and insert into cells.
2. They can replicate independently of the host cell's chromosome, allowing for high copy numbers of the inserted gene.
3. They often contain marker genes (e.g., antibiotic resistance) for selection of transformed cells.
4. They have restriction sites for the insertion of foreign DNA.

M A R K S C H E M E

- ✓ Small/circular DNA. [1 mark]
- ✓ Can replicate independently. [1 mark]
- ✓ Contain marker genes/antibiotic resistance genes. [1 mark]
- ✓ Have restriction sites. [1 mark] (Any two)

Question 7 (4 marks)

> *Explain the importance of using the same restriction endonuclease to cut both the desired gene and the plasmid vector.*

MODEL ANSWER

Using the same restriction endonuclease ensures that both the desired gene and the plasmid vector are cut at specific, identical recognition sequences. This results in the production of complementary sticky ends on both DNA fragments. These complementary sticky ends can then anneal/base pair with each other, allowing the desired gene to be inserted into the plasmid in the correct orientation. If different enzymes were used, the sticky ends would not be complementary, and the gene would not be able to ligate into the plasmid effectively.

MARK SCHEME

- ✓ Cuts at specific/identical recognition sequences. [1 mark]
- ✓ Produces complementary sticky ends on both gene and plasmid. [1 mark]
- ✓ Allows gene and plasmid to anneal/base pair. [1 mark]
- ✓ Enables successful ligation/insertion of the gene into the plasmid. [1 mark]

Question 8 (3 marks)

> *Describe the role of DNA ligase in the formation of recombinant DNA.*

MODEL ANSWER

DNA ligase is an enzyme that forms phosphodiester bonds between the sugar-phosphate backbone of the inserted gene and the plasmid DNA. After the complementary sticky ends have annealed, DNA ligase seals the nicks in the backbone, permanently joining the foreign DNA into the vector to create a continuous, stable recombinant DNA molecule.

MARK SCHEME

- ✓ Forms phosphodiester bonds. [1 mark]
- ✓ Between the sugar-phosphate backbone. [1 mark]
- ✓ To permanently join the inserted gene and the vector DNA/seal the nicks. [1 mark]

Question 9 (6 marks)

> *Scientists used recombinant DNA technology to insert a gene for herbicide resistance into a crop plant. The process involved several stages, including transformation and selection. Explain how marker genes are used to identify successfully transformed cells.*

MODEL ANSWER

Marker genes are typically inserted into the vector along with the desired gene (e.g., herbicide resistance). A common marker gene confers resistance to an antibiotic or produces a visible product like a fluorescent protein. After transformation, the plant cells are grown on a selective medium containing the antibiotic or substance that the marker gene provides resistance to. Only cells that have successfully taken up and expressed the vector containing the marker gene (and thus the desired herbicide resistance gene) will survive and grow. Untransformed cells, or those that have not incorporated the vector, will die. This allows for the identification and isolation of the successfully transformed cells, which can then be regenerated into whole plants.

MARK SCHEME

- ✓ Marker gene (e.g., antibiotic resistance gene) is inserted into the vector along with the desired gene. [1 mark]
- ✓ After transformation, cells are grown on a selective medium. [1 mark]
- ✓ This medium contains a substance (e.g., antibiotic) that the marker gene provides resistance to. [1 mark]
- ✓ Only cells that have successfully taken up and expressed the marker gene (and thus the desired gene) will survive/grow. [1 mark]
- ✓ Untransformed cells/cells without the vector will die. [1 mark]
- ✓ Allows for identification/selection/isolation of successfully transformed cells. [1 mark]

Question 10 (5 marks)

A genetic engineer has isolated a gene of interest and wants to amplify it using the Polymerase Chain Reaction (PCR).

Component	Concentration (μmol dm^{-3})	Volume (μL)
Template DNA	*0.01*	*2*
Forward primer	*10*	*2*
Reverse primer	*10*	*2*
dNTPs	*2.5*	*4*
Taq polymerase	*0.05 units/μL*	*1*
Buffer	*10×*	*5*
Sterile water	*-*	*X*
Total reaction volume	*-*	*50*

Calculate the volume of sterile water (X) required for this PCR reaction. Show your working.

MODEL ANSWER

Total volume of components added so far = Volume of Template DNA + Volume of Forward primer + Volume of Reverse primer + Volume of dNTPs + Volume of Taq polymerase + Volume of Buffer
Total volume = 2 μL + 2 μL + 2 μL + 4 μL + 1 μL + 5 μL = 16 μL

Volume of sterile water (X) = Total reaction volume - Total volume of components added so far
X = 50 μL - 16 μL = 34 μL

Therefore, 34 μL of sterile water is required.

STEP-BY-STEP WORKING

Step 1: Identify all the volumes of the components already listed in the table.
Step 2: Sum these volumes: 2 μL (Template DNA) + 2 μL (Forward primer) + 2 μL (Reverse primer) + 4 μL (dNTPs) + 1 μL (Taq polymerase) + 5 μL (Buffer) = 16 μL.
Step 3: Subtract this sum from the total desired reaction volume.
Step 4: 50 μL (Total reaction volume) - 16 μL (Sum of components) = 34 μL.
Step 5: The volume of sterile water (X) required is 34 μL.

MARK SCHEME

- ✓ Identifies all component volumes to be summed. [1 mark]
- ✓ Correctly sums component volumes (2+2+2+4+1+5 = 16 μL). [2 marks]
- ✓ Subtracts sum from total reaction volume (50 - 16). [1 mark]
- ✓ Correct final answer (34 μL). [1 mark]

Question 11 (7 marks)

> *Discuss the ethical considerations surrounding the use of recombinant DNA technology in agriculture, specifically focusing on genetically modified (GM) crops.*

MODEL ANSWER

See model answer.

MARK SCHEME

✓ See marking points [7 marks]

Question 12 (4 marks)

> *Explain the purpose of a promoter region and a terminator region in the expression of a foreign gene in a host cell.*

MODEL ANSWER

See model answer.

MARK SCHEME

✓ See marking points [4 marks]

Question 13 (8 marks)

> *Describe the process of gene cloning using a bacterial plasmid, from the isolation of the desired gene to the production of multiple copies of the gene within bacterial cells. Include details on how the desired gene is identified and selected.*

MODEL ANSWER

See model answer.

MARK SCHEME

✓ See marking points [8 marks]