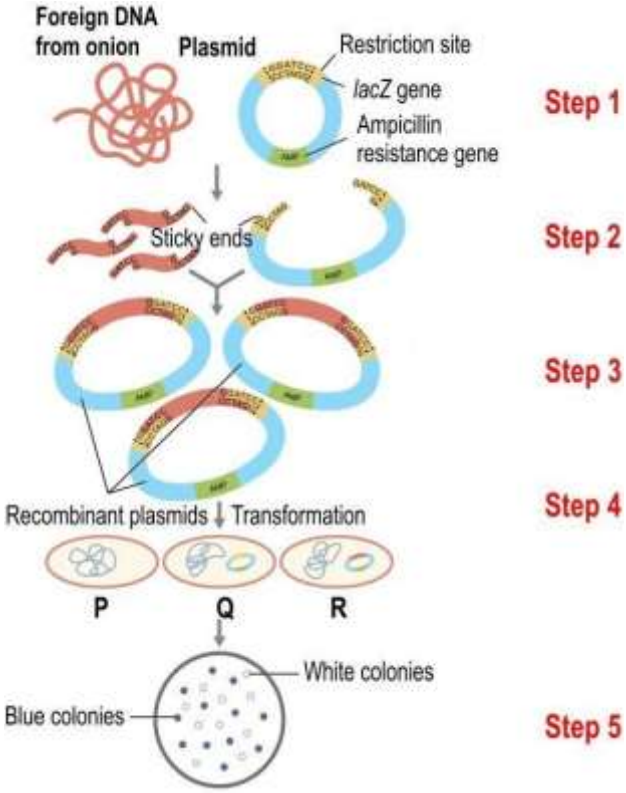
2. BIOTECHNOLOGY AND ITS APPLICATIONS

Q. No	Question	Marks
	Multiple Choice Questions	
Q.3	There are two statements given below marked as Assertion (A) and Reason (R). Read the statements and choose the correct option. Assertion: RNA interference (RNAi) is used to protect plants against nematode infestation. Reason: RNAi method involves silencing of a specific mRNA by a complementary dsRNA molecule that binds to and prevents translation of the mRNA. A. A is true but R is false. B. A is false but R is true. C. Both A and R are true and R is the correct explanation of A. D. Both A and R are true and R is not the correct explanation of A.	1
Q.4	Given below are steps involved in the gene therapy of a patient with adenosine deaminase (ADA) deficiency. P) Lymphocytes are grown in a culture outside the human body. Q) Lymphocytes are altered with a functional ADA cDNA. R) Lymphocytes are collected from the blood of the patients. S) The genetically modified lymphocytes are infused back into the patient. Which of the following show the correct order in which these steps must occur? A. Q --> P --> R --> S B. R --> S --> Q --> P C. R --> P --> Q --> S D. S --> R --> P --> Q	1
	Given below is an image of the process involved in recombinant DNA technology. LacZ is a gene that codes of β-galactosidase. When plated on an appropriate medium, cells that produce β-galactosidase form blue colonies whereas those that do not produce it form white colonies.	



Answer the Questions from Q5-Q8

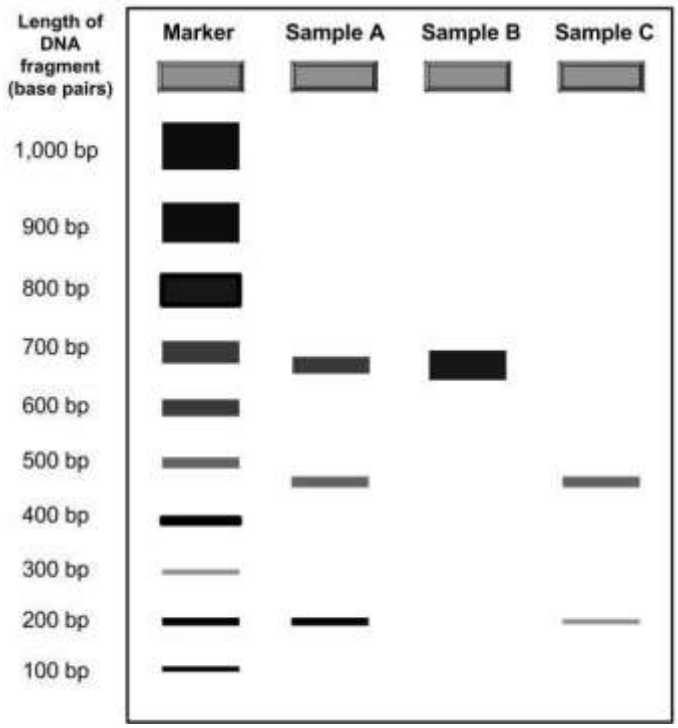
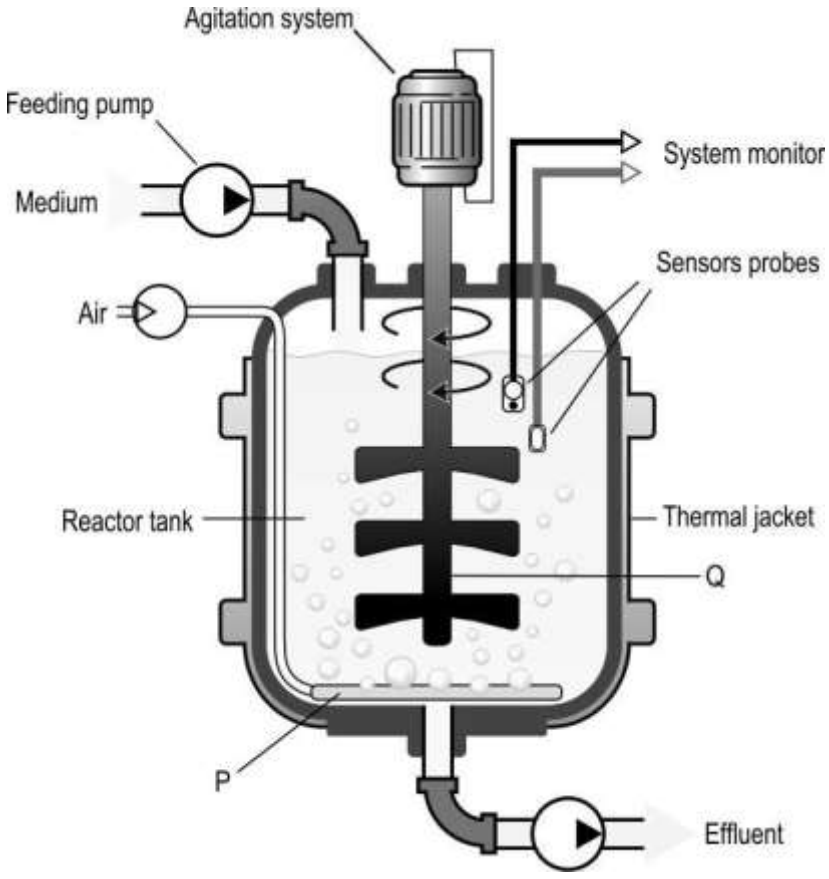
Q.5	Which of the following chemicals will be involved in a step that would come before step 1? lysozyme, ethanol, ribonuclease, cellulase, protease A. only lysozyme and ethanol B. only cellulase, lysozyme and ethanol C. only lysozyme, ribonuclease, protease, and ethanol D. all - lysozyme, ethanol, ribonuclease, cellulase, protease	1
Q.6	Which of the following will help one detect cells containing the recombinant DNA? A. A B. B C. C D. D	1
Q.7	At which step will DNA ligase be required? A. step 2	1

Option	Ampicillin in medium	colour of colonies formed
A	present	blue colonies
B	absent	blue colonies
C	present	white colonies
D	absent	white colonies

	B. step 3 C. step 4 D. (DNA ligase is not required in this process)	
Q.8	What would be the colour of the colonies formed by variant P? A. only blue colonies B. only white colonies C. a mix of blue and white colonies D. (They will not form any colonies.)	1
Q.9	Polymerase chain reaction (PCR) mimics which of the following natural processes? A. ligation B. translation C. replication D. transformation	1
Q.10	Which of the following correctly states the purpose of steam in a bio-processor? A. helps organisms grow faster B. adds to the water content C. maintains sterility D. (Steam is not required in a bio-processing unit.)	1
Q.11	Similar to sexual reproduction, rDNA technology contributes to_____. P) genetic mutation Q) faster replication R) genetic variation S) DNA ligation A. only R B. only P and R C. only P, Q and R D. all - P, Q, R and S	1
Q.12	In which of the following natural processes is recombinant DNA made? A. prophase in mitosis B. prophase 1 in meiosis C. prophase 2 in meiosis D. (Recombinant DNA cannot be made naturally).	1
Q.13	Two statements are given below - one labelled Assertion (A) and the other labelled Reason (R).	1

	Assertion (A): Sexual reproduction is similar to rDNA technology because it results in variations. Reason (R): Variation is impossible through asexual reproduction. Which of the following is correct? A. Both A and R are true, and R is the correct explanation for A. B. Both A and R are true, but R is not the correct explanation for A. C. A is true, but R is false. D. A is false, but R is true.	
Q.14	Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Assertion (A): Gene therapy is a method of treating a disorder but cannot cure it. Reason (R): In gene therapy, cells are drawn from a patient and the functional gene is introduced into these cells and transferred back to the patient. Which of the following is correct? A. Both A and R are true, and R is the correct explanation for A. B. Both A and R are true, but R is not the correct explanation for A. C. A is true, but R is false. D. A is false, but R is true.	1
Q.15	Given below are two statements about polymerase chain reactions. P) It mimics DNA replication that happens in a cell. Q) It cannot be used to amplify RNA molecules. Which of these is/are TRUE? A. only P B. only Q C. both P and Q D. neither P nor Q	1
Free Response Question/ Subjective Question		
Q.16	X is the first restriction enzyme isolated from strain H of Bacillus amyloliquefaciens. This enzyme cuts between two guanine bases of the following palindromic sequence: 5'-G G A T C C-3' 3'-C C T A G G-5' (a) Name the restriction enzyme X. Explain how you arrived at this name. (b) Draw the DNA fragments produced due to the action of enzyme X on the palindromic sequence shown above.	3

<table>
<tr><td>Q.17</td><td>In 1997, an American company obtained patent rights on Basmati rice, allowing them to market a 'new' strain of Basmati rice in the United States and overseas. This 'new' Basmati strain was really derived from Indian farmer's varieties.
(a) What is this unauthorised act called? Define it.
(b) State TWO ways in which Indian farmers are set to lose due to this unauthorised act.
(c) State TWO measures that different countries are taking to prevent such unauthorised exploitation of their bio-resources.</td><td>3</td></tr>
<tr><td>Q.18</td><td>(a) What are transgenic animals?
(b) To produce transgenic animals, the gene of interest is introduced into embryonic stem cells. These stem cells are undifferentiated and the preferred target in the process of developing any transgenic animal. Give a reason why.</td><td>2</td></tr>
<tr><td>Q.19</td><td>CRISPR is a gene editing technique for which the developers won the Nobel Prize. Indian scientists are in the process of developing resilient and high-yield varieties of rice using this technology and providing these to Indian farmers by 2024, once approved.
(a) Which organisation would be responsible for approving such varieties?
(b) What is the purpose of establishing the organisation identified in (a)?</td><td>2</td></tr>
<tr><td>Q.20</td><td>Kavya and David needed to cut out a 200 base-pair (bp) long DNA fragment from a 650 bp long vector. Enzyme A cuts at 350 bp and at 550 bp whereas enzyme B does not cut the vector. They followed the given steps to do this:
<table><tr><th>Step</th><th>David</th><th>Kavya</th></tr><tr><td>1</td><td>Take 3 micrograms of the vector</td><td>Take 3 micrograms of the vector</td></tr><tr><td>2</td><td>Add 2 microlitres of enzyme A</td><td>Add 2 microlitres of enzyme B</td></tr><tr><td>3</td><td>Incubate at 37°C for 2 hours</td><td>Incubate at 37°C for 2 hours</td></tr><tr><td>4</td><td>Run the sample on an agarose gel</td><td>Run the sample on an agarose gel</td></tr></table>Given below is an image of the gel that was run with the samples.</td><td>3</td></tr>
</table>

	 (a) What is the purpose of the marker? (b) Which of these shows the samples run by David and Kavya? Justify your answer.	
Q.21	Given below is a diagram of a bio-reactor with some of its parts labelled P and Q. 	3

	(a) Which type of organisms can MOST likely be used if part P is not made a part of the bio-reactor? Why? (b) Identify the name and purpose of part Q. (c) How does the thermal jacket help in the process?	
Q.22	(a) Give a reason why, although a toxin, Bt toxins are deadly for insects but not for plants producing them. (b) Describe the steps in which Bt toxins act on insects.	3
Q.23	Plants of a region in India are constantly infested by the corn borer. (a) What components are required in a recombinant plasmid that can produce modified plants which are resistant to the corn borer? State the purpose of each component. (b) Give an example of a plasmid that can be used for (a).	2
Q.24	Identify if the following statement is true or false. Between formation of the dsRNA and silencing of mRNA, the dsRNA needs to undergo an additional step. Justify if true, and rewrite the correct statement, if false.	2
Q.25	Hormones are broadly categorised as steroid hormones and protein hormones. Patients with type 2 diabetes, generally, have to take insulin externally. Researchers across the world believe that if insulin can be given orally it would be ideal as it would closely mimic the movement of natural insulin. Yet, injectable insulin is commonly prescribed by doctors. What type of a hormone is insulin and why can't it be administered orally?	2
Q.26	(a) What causes adenosine deaminase (ADA) deficiency? (b) What are the THREE methods that are currently used for the treatment of ADA? (c) What is the problem with the methods described in (b)? How can this problem be overcome?	3
Q.27	Give a reason why: (a) Transgenic animals are used for the production of biological components of medicines over synthetic industrial production. (b) In the process of testing for effects of chemicals, transgenic animals are used rather than non-transgenic ones.	2
Q.28	Naturally growing potatoes show bruises (black discolouration) when they get damaged. Bruising occurs when the tissue is crushed and cells rupture, releasing enzymes that produce a black discolouration. A gene has been	5

<table>
<tr><td></td><td>identified which codes for this enzyme. A company wants to produce potatoes that do not show these bruises.

(a) Describe the steps in which they can produce such potatoes that do not show bruises.

(b) What is the process called?</td><td></td></tr>
<tr><td>Q.29</td><td>(a) What is a disadvantage of the traditional hybridisation procedure?

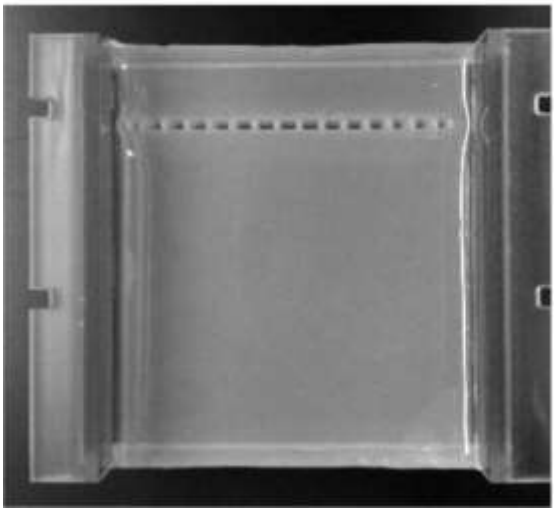
(b) How has rDNA technology overcome the disadvantage identified in (a)?</td><td>2</td></tr>
<tr><td>Q.30</td><td>Anita and Dipti followed the steps mentioned below to introduce their gene of interest into the target organism.

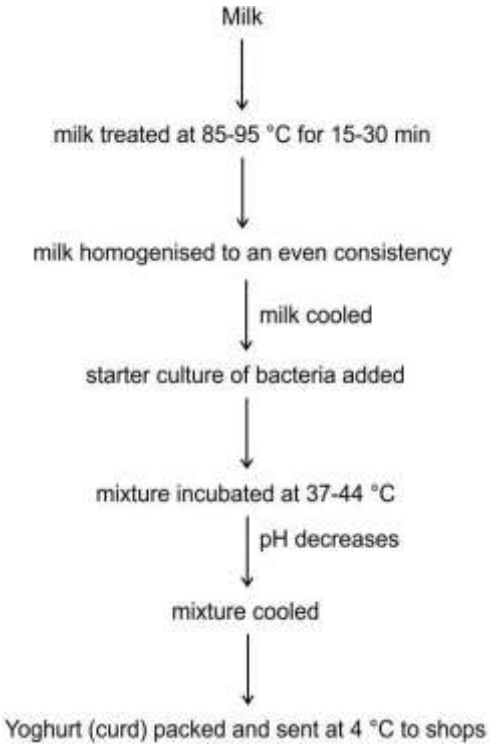
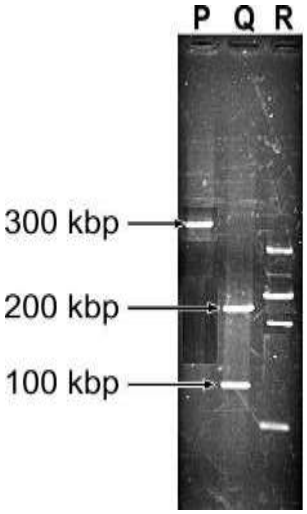
<table><tr><th>Step</th><th>Anita</th><th>Dipti</th></tr><tr><td>1</td><td>used a restriction enzyme to obtain gene of interest</td><td>used a restriction enzyme to obtain gene of interest</td></tr><tr><td>2</td><td>made multiple copies of the gene of interest using PCR</td><td>ligated the gene of interest with a cloning vector</td></tr><tr><td>3</td><td>introduced the amplified genes in the cell</td><td>introduced the vector prepared in step 2 in the cell</td></tr></table>
Of these, whose experiment is more likely to succeed and why?</td><td>2</td></tr>
<tr><td>Q.31</td><td>Golden rice is a variety of rice that has been genetically modified to produce a compound called β-carotene, which gets converted to Vitamin A when metabolised in the human body. This was done by introducing the genes coding for three enzymes - 'psy' and 'LCYB' from daffodil and 'crtI' from the soil bacterium Erwinia uredovora.

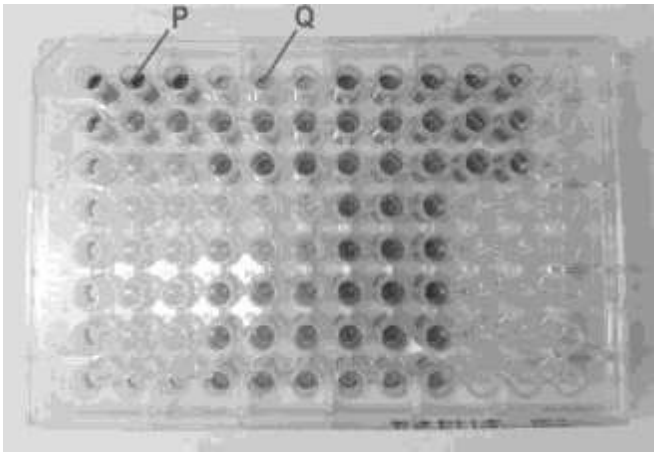
(a) With the help of a diagram, describe the process by which golden rice can be made.

(b) Name the vector used in the process.

(c) Give a reason why the vector identified in (b) should be used.</td><td>5</td></tr>
<tr><td>Q.32</td><td>Karan wanted to cut a DNA fragment which was 800 base-pairs long from a vector. He followed each step of the protocol correctly and ran the resultant sample on an agarose gel. In an earlier attempt in extracting DNA from onion cells, he had seen DNA form a thread like precipitate in ethanol. Given below is an image of the gel after he finished running his sample in it.</td><td>2</td></tr>
</table>

	 (a) Why does he not see the same thread like precipitate in the gel? (b) How can he ensure he has obtained the desired result?	
Q.33	Papaya is a widely cultivated crop in several regions. However, its production was limited by papaya ringspot disease which is caused by the Papaya ringspot virus (PRSV). Papaya plants infected by PRSV show symptoms of yellowing, discolouration of leaves and 'ringspots' on the fruit. PRSV belongs to the genus Potyvirus which has a single-stranded RNA as its genetic material. (a) Explain the step-by-step process to inhibit the viral RNA from surviving in the papaya plants thus creating disease-resistance varieties of papaya. (b) Name the biotechnological process described in (a) and give a reason why it is the appropriate process to be used in this case.	5
Q.34	Growth hormone injection treatment is prescribed for children who have been diagnosed with growth hormone (GH) deficiency and other conditions causing short stature and insufficient growth. This hormone is produced by the pituitary gland in humans so the gene for this hormone was isolated from the pituitary gland and introduced into phGH407 vectors for production. However, a problem with this was that the protein so produced was 26 amino acids longer than the active growth hormone (24 amino acids long) and so this method could not be used. (a) Given that the amino acid sequence of the active growth hormone was known, use a diagram to explain how human growth hormone could be produced outside the body. (b) The vector consists of a lac gene which codes for the enzyme β-galactosidase. Describe how this gene can help with the selection of colonies containing the transgene.	5
Q.35	Given below is the step-by-step process in the formation of yoghurt (curd) in a bioreactor.	3

	 (a) Why does the pH start decreasing a while after the mixture is incubated at 37-44 °C? (b) From the flowchart, identify two systems that the bioreactor would have. Give a reason to support your answer.	
Q.36	Nidhi performed gel electrophoresis after treating one vector with restriction enzymes. She added one mixture in well Q and another mixture in well R. Given below is an image of the results.  (a) What can be concluded about the mixtures loaded in wells P and Q? (b) What is the likely reason that the fragments in wells Q and R are different?	2
Q.37	ELISA is a test used for early detection of an infection.	3

	What components of a disease can be detected using ELISA? Describe the components that can be checked if one wants to identify whether an individual is allergic to pollen or not. Given below is an image of an ELISA test result with two of its cells marked P and Q. A coloured cell indicates a positive result whereas an uncoloured cell is a negative result.  (c) The colour of P is darker than the colour of Q. What could this possibly indicate?	
Q.38	Explain why vectors that have restriction site/s within a marker gene are preferred, for recombinant DNA technology.	2

Answer Key & Marking Scheme

Q.No	Answers	Marks
Q.3	C. Both A and R are true and R is the correct explanation of A.	1
Q.4	C. R --> P --> Q --> S	1
Q.5	D. all - lysozyme, ethanol, ribonuclease, cellulase, protease	1
Q.6	C. C	1
Q.7	B. step 3	1
Q.8	D. (They will not form any colonies.)	1
Q.9	C. replication	1
Q.10	C. maintains sterility	1
Q.11	B. only P and R	1
Q.12	B. prophase 1 in meiosis	1
Q.13	C. A is true, but R is false.	1
Q.14	A. Both A and R are true, and R is the correct explanation for A.	1
Q.15	A. only P	1
Q.16	(a) 0.5 marks for each of the following: - Name of the enzyme: BamHI - The convention used to name a restriction enzyme is the first letter comes from the genus (Bacillus) and next two letters from the species (amyloliquefaciens). - The fourth letter refers to the strain (strain H). - The roman number in the end indicating the order in which the enzyme was isolated from the strain (first enzyme). (b) 5'-G G A T C C-3' 3'-C C T A G-5'	3
Q.17	(a) 0.5 marks each for the correct name and its definition:	3

	- biopiracy - refers to the use of bio-resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment. (b) 0.5 marks each for the following: - authorisation - compensation (c) 0.5 marks each for any two correct points such as: - Benefits of bio-resources should be shared between developed and developing countries. - Implementing laws for issues such as patent terms emergency provisions and research and development initiative. [Marks to be awarded for any other correct answer]	
Q.18	(a) Animals that have had their DNA manipulated to possess and express an extra (foreign) gene are transgenic animals. (b) Since embryonic stem cells are undifferentiated, they have the capability of forming all other cells of the body with their specialised functions and the inserted foreign gene.	2
Q.19	(a) GEAC (Genetic Engineering Approval Committee) OR GEAC (Genetic Engineering Appraisal Committee) [No marks to be awarded if the full form is not mentioned] (b) 0.5 marks each for the following: - Provide decisions regarding the validity of GM research. - Ensure the safety of introducing GM-organisms for public services [Accept any other valid point]	2
Q.20	(a) The marker acts as reference to identify the size of the fragments that are visible on the gel. (b) 0.5 marks each for identification and justification: - Sample C belonged to David. - David followed the procedure properly and so can see two correct bands (200 bp of the fragment and 450 bp of the remaining vector). - Sample B belonged to Kavya	3

	- Since enzyme B does not cut the vector, it remained intact when run on the gel.	
Q.21	(a) Anaerobic organisms Reason - since the aerator ensures supply of oxygen for aerobic organisms to respire and function, anaerobic organisms will not need this to carry out life processes. (b) Q - stirrer/agitator Purpose - The stirrer facilitates even mixing and oxygen availability throughout the bio-reactor. (c) to maintain temperature throughout the process	3
Q.22	(a) Bt toxins exists as inactive protoxins when produced by the plant and become active only when they are ingested by insects. (b) 0.5 marks for each of the following points: - A plant/part of plant producing bt toxins is ingested by an insect. - The inactive protoxin form of the bt toxin gets converted into an active form of toxin due to the alkaline pH of the gut which solubilises the crystals. - The activated toxin binds to the surface of midgut epithelial cells and create pores. - These pores cause cell swelling and lysis and eventually cause death of the insect.	3
Q.23	(a) 0.5 marks for each of the following components along with their purpose: - a cloning site with the cryIAb gene inserted in it to produce the toxin - a selectable marker such as an antibiotic resistance gene for selection of colonies with the recombinant plasmid - an origin of replication so that the plasmid can replicate and make copies [no marks to be awarded for component if purpose is not mentioned] (b) Ti plasmid from Agrobacterium tumifaciens	2
Q.24	- True [1 mark] - Justification: Since dsRNA is double stranded, it cannot automatically bind to the mRNA. So the two strands must be separated so that a single stranded RNA is obtained which can bind to the single stranded mRNA, silencing it. [1 mark]	2
Q.25	1 mark each for the following: - Insulin is a protein hormone.	2

	- If taken orally, they will get digested by pepsin and trypsin in the stomach and small intestine into their simpler forms, thereby losing their function.	
Q.26	(a) ADA is caused due to the deletion of the gene coding for adenosine deaminase. (b) 0.5 marks each for the following methods: - bone marrow transplantation - enzyme replacement therapy - gene therapy (c) 0.5 marks for each of the following: Problem - all three methods are not completely curative. Way to overcome - introducing the gene coding for ADA from marrow cells into early embryonic cells could permanently cure the disorder.	3
Q.27	(a) 1 mark for any one correct reason such as: - Industrial production is expensive when compared to production through transgenic animals. - The components produced by transgenic animals have the possibility of being as close to the natural product as possible. (b) Transgenic animals are made that carry genes which make them more sensitive to toxic substances than non-transgenic animals allowing for results in lesser time.	2
Q.28	(a) 1 mark each for the following points: - Creating a Ti plasmid which have the sense and anti-sense RNA, the latter complimentary to the mRNA coding for the enzyme. - Introducing these plasmids into the host plant. - The sense and anti-sense RNA would combine to form a dsRNA - The two strands split and the anti-sense RNA binds to the mRNA coding for the enzyme causing the black discolouration, silencing it. (b) RNA interference (RNAi)	5
Q.29	(a) Traditional hybridisation procedures very often lead to inclusion and multiplication of undesirable genes along with the desired genes. (b) Using rDNA technology, only the desired gene can be introduced into an organism without introducing other undesirable gene.	2
Q.30	- Dipti's experiment is more likely to succeed. [1 mark]	2

	- Since Anita introduce her gene as it is, it did not have an origin of replication to replicate on its own and would get degenerated over time. [1 mark]	
Q.31	(a) Correct illustration of the process - drawing 3 genes of interest from 2 sources, inserting them into a plasmid cut with the same restriction enzyme, introducing the plasmid into rice embryos/cells [2 marks] - Step by step description of the process with correct terminology [2 marks] (b) Ti plasmid (c) Ti plasmid can replicate well in the plant genome/Its genes can be expressed in the environment of the plant genome.	5
Q.32	(a) When DNA is extracted from several cells, it is much bigger in size than 800 base-pairs and is present in a larger volume and so can be seen with the naked eye. [Accept any other valid answer] (b) When stained with ethidium bromide and kept under UV light, the agarose gel should show a band of DNA corresponding to 800 base-pairs on the marker.	2
Q.33	(a) 0.5 marks each for the following: - The viral RNA is isolated and converted to a dsDNA structure. - The dsDNA so formed is inserted into an appropriate vector (Agrobacterium or viral vector). - The vectors are then introduced into the host plant where it transcribes the mRNA for this gene. - Whenever the virus infects the plant and injects its RNA into the host plant, the host plant transcribes the viral RNA. - The mRNA produced from the vector binds to the transcribed viral RNA. - This prevents the viral RNA from being transcribed and therefore survives in the host plant without infecting the plant. (b) 1 mark each for the following: - RNAi or RNA interference - RNAi helps in in-vitro silencing of a gene/set of genes so that they lose their function.	5
Q.34	(a) 1 mark each for each of the following step explained in a diagram: - From the amino acid sequence, the gene for growth hormone needs to be synthesized chemically. - The gene of interest is cut using a restriction enzyme and the same restriction enzyme is used to cut the vector within the lac gene.	5

	- The gene obtained is inserted into the vector using a ligase. - These are transformed into E.coli cells/host cells for production. (b) 0.5 marks each for the following: - In recombinants, since the lac gene is inactivated, after insertion of the gene of interest, it does not produce the β-galactosidase enzyme which results in colourless colonies when a chromogenic substrate is added. - In non-recombinants, since the lac gene is still active, it produced the enzyme β-galactosidase which results in blue colonies when a chromogenic substrate is added.	
Q.35	(a) 0.5 marks for each of the following: - As the bacteria starts to grow, it uses up the oxygen in the system. - After a while, the oxygen gets used up and anaerobic respiration begins which leads to the formation of lactic acid, causing a decrease in the pH. (b) 0.5 marks for identification and 0.5 marks for the reason for any TWO of the following: - Oxygen delivery system: After the starter culture is added, oxygen is also added which will need a delivery system. - Stirrer: Once oxygen is added, the system would need to be mixed thoroughly so that oxygen is available throughout the bioreactor. - Sterilization unit: Milk needs to be sterilised before addition of the starter culture to remove any other microorganisms already present in it. [Accept any other valid answer]	3
Q.36	(a) Well P contains the uncut vector whereas well Q contains the vector cut by a restriction enzyme. (b) The vector in well Q has been cut by a restriction enzyme that has two sites whereas the vector in well R has been cut either by different enzymes or by one enzyme that has more than two sites.	2
Q.37	Presence of antigen/antibodies to an antigen can be detected using ELISA. 0.5 marks for each of the following: antigen from pollen IgE antibodies (c) P may have more antigen/antibodies as compared to Q.	3
Q.38	1 mark each for the following: - When a target gene gets inserted into a marker gene which has a restriction site, it inactivates the production of the marker	2

	- The absence of a characteristic that was coded for by the marker is useful in the detection of cells with the recombinant vectors. [Accept any other valid answer]	