

Marking Schemes

This document was prepared for markers' reference. It should not be regarded as a set of model answers. Candidates and teachers who were not involved in the marking process are advised to interpret its contents with care.

Paper 1

SECTION A

Question No.	Key	Question No.	Key
1.	C (64%)	21.	A (72%)
2.	D (60%)	22.	D (49%)
3.	A (56%)	23.	B (53%)
4.	A (42%)	24.	D (32%)
5.	C (48%)	25.	C (47%)
6.	D (42%)	26.	C (81%)
7.	B (68%)	27.	B (39%)
8.	A (67%)	28.	A (54%)
9.	B (44%)	29.	A (77%)
10.	B (82%)	30.	C (64%)
11.	B (54%)	31.	C (63%)
12.	D (69%)	32.	B (75%)
13.	D (21%)	33.	C (69%)
14.	A (66%)	34.	D (94%)
15.	B (60%)	35.	C (64%)
16.	B (61%)	36.	C (70%)
17.	D (57%)		
18.	A (54%)		
19.	B (51%)		
20.	A (42%)		

Note: Figures in brackets indicate the percentages of candidates choosing the correct answers.

General Marking Instructions

1. In order to maintain a uniform standard in marking, markers should adhere to the marking scheme agreed at the markers' meeting.
2. The marking scheme may not exhaust all possible answers for each question. Markers should exercise their professional discretion and judgment in accepting alternative answers that are not in the marking scheme but are correct and well-reasoned.
3. The following symbols are used:

/ A single slash indicates an acceptable alternative within an answer. * Correct spelling required

4. In questions asking for a specified number of reasons or examples etc. and a candidate gives more than the required number, the extra answers should not be marked. For instance, in a question asking candidates to provide two examples, if a candidate gives three, only the first two should be marked.
5. In cases where a candidate answers more questions than required, the answers to all questions should be marked. However, the excess answer(s) receiving the lowest score(s) will be disregarded in the calculation of the final mark.
6. Award zero marks for answers which are contradictory.

Paper 1 Section B

		<u>Marks</u>
1.	(a) 100.8 mm ² (1) [no unit, no mark]	(1)
	(b) <div style="border: 1px solid black; padding: 5px;"> Concept for mark award: <ul style="list-style-type: none"> • correct comparison of the surface area / surface area to volume ratio (1) • significance of the difference to the diffusion of gases (1) </div> e.g. <ul style="list-style-type: none"> • for the same volume, 8 small spheres have a larger total surface area / a larger surface area to volume ratio than a large sphere (1) • therefore, the diffusion rate for gas exchange will be higher / diffusion of gases will be faster (1) 	(2)
	(c) any one of the following: <ul style="list-style-type: none"> • thin wall (made up of a single layer of cells) offers a short diffusion distance for rapid gas exchange (1) • some cells in the wall secrete fluid / the presence of a water film on the inner wall for gas dissolution / allowing gases to dissolve (1) 	(1)
		<hr style="width: 100%; border: 0.5px solid black;"/> 4 marks
2.	(a) <div style="border: 1px solid black; padding: 5px;"> Concept for mark award: <ul style="list-style-type: none"> • description of how the presence of organelles affects the lens (1) • description of how it affects the image formed (1) </div> e.g. <ul style="list-style-type: none"> • light is scattered by the presence of organelles / some light is blocked by the presence of organelles / the lens will become unclear (1) • images formed on the retina become unclear / blurred / light cannot focus correctly on the retina (1) 	(2)
	(b) Any one of the following: <ul style="list-style-type: none"> • xylem tube / xylem vessel (1) with all the cell content degraded to form a hollow tube which provides little resistance to water transport (1) • sieve tube (1) with reduced cell content which offers a lower resistance to the translocation of sucrose (1) 	(2)
		<hr style="width: 100%; border: 0.5px solid black;"/> 4 marks
3.	(a) • muscle P is contracting (1)	(1)
	(b) • Muscle P is a <u>flexor</u> because <u>the contraction of P bends the joint at Y / P contracts to bend joint Y.</u> (1)	(1)
	(c) • without Q to hold the two bones together / Q cannot hold the bones together / dislocation of the bones at joint Y (1)	(2)
	• it will be difficult to move the leg at joint Y (1)	(1)
		<hr style="width: 100%; border: 0.5px solid black;"/> 4 marks
4.	(a) • it is transmitted by vector / mosquitoes (1)	(1)

- (b)

Concept for mark award: <ul style="list-style-type: none"> • correct environmental factor + its effect on mosquitoes (1x2) • overall effect on population (1)

 (3)
- e.g.
- mosquitoes have a faster growth rate / be more active when the temperature is higher / when it is warmer (1)
 - mosquitoes have more breeding grounds during rainy seasons (1)
 - therefore, the mosquito population is larger in tropical and subtropical regions (1) resulting in disease spreading more easily
- (c) (i)

<ul style="list-style-type: none"> • B lymphocytes / plasma cells produce antibodies to neutralise the dengue viral particles / aggregate the viral particles, preventing them from entering the body cells (1) • phagocytes engulf the aggregated viral particles (1) • T lymphocytes recognise and kill the body cells which have been infected by the virus (1)

 (3)
- (ii)

<ul style="list-style-type: none"> • the different subtypes of DENV may have antigens different from one another (1) • as a result, the memory cells produced after the infection of one subtype may not be able to recognise antigens of other subtypes (1)

 (2)
- (d)

<ul style="list-style-type: none"> • use insect repellent / wear long-sleeve clothes and trousers / wear clothes with light colours / remove stagnant water bodies (accept other reasonable answers) (1)

 (1)
-
- 10 marks
5. (a)

<ul style="list-style-type: none"> • thylakoid* / thylakoid* membrane (1)

 (1)
- (b)

Concept for mark award: <ul style="list-style-type: none"> • energy conversion at X (1) • significance of the energy conversion in photosynthesis (1)

 (2)
- e.g.
- light energy is captured in X and converted to chemical energy (1)
 - to provide energy in the form of NADPH and ATP for Calvin cycle / dark reactions / carbon fixation (1)
- (c)

Concept for mark award: <ul style="list-style-type: none"> • correct identification of the type of metabolism (1) • example of the usage of energy to construct large molecules from small molecules (1)

 (2)
- e.g.
- they are anabolic in nature / they are anabolic reactions / they belong to anabolism (1)
 - using the energy captured to produce 3-C compounds / triose phosphate / glucose / starch / carbohydrates from carbon dioxide (1-C) (1)

- (d)

<p>Concept for mark award:</p> <ul style="list-style-type: none"> • conversion of photosynthetic products to transport form (1) • path of transport including tissue involved (1) • conversion of transport form to storage form (1) 	(3)
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e.g.

- photosynthetic products (e.g. 3-C compounds, glucose, triose phosphate, starch, carbohydrates) are converted to sucrose for transport (1)
- along the phloem from leaves through stem, and then to the underground tubers (1)
- sucrose is converted to starch for storage in the underground tubers (1)

8 marks

6. (a) • one type of cone cell / the cone cells for detecting green spectrum do not function in red-green colour blindness while all three types of cone cells do not function in total blindness (1)

- (b)

<p>Concept for mark award:</p> <ul style="list-style-type: none"> • correct comparison of the occurrence of red-green colour blindness in men and women with that of total colour blindness in men and women (1) • relate X-linked inheritance to the greater chance of men suffering from red-green colour blindness (2) • relate autosomal inheritance to the same chance of suffering from total colour blindness in both sexes (1) 	(4)
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e.g.

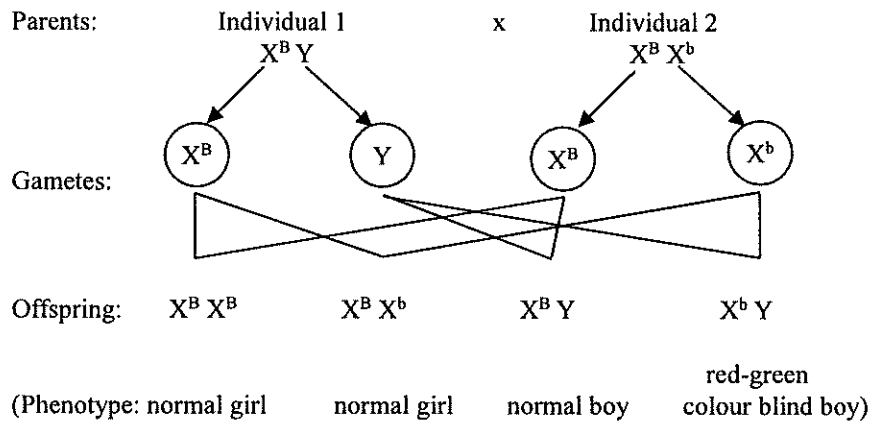
- the percentage of men suffering from red-green colour blindness is greater than that of women, while the percentage of men suffering from total colour blindness is the same as that of women (1)
- the allele for red-green colour blindness is located on the X-chromosome, since men have only one X-chromosome, they will have the disorder once they receive an X-chromosome carrying the recessive allele / allele for red-green colour blindness (1)
- women have two X-chromosome, so they will have the disorder only if they have recessive alleles on both X-chromosomes / the effect of the recessive allele will be masked by the effect of the dominant allele (1), as a result, women have a lower chance of having red-green colour blindness
- the allele for total colour blindness is located on an autosome, so both men and women have an equal chance of inheriting the recessive allele / allele for total colour blindness (1)

- (c) (i) Concept for mark award:
- format (1)
 - genotypes of parents (1)
 - gametes and genotype combinations of offspring (1)
 - correct probability (1)

(4)

e.g.

Let X^B be the X chromosome carrying the allele for normal vision
 X^b be the X chromosome carrying the allele for red-green colour blindness
 Y be the Y chromosome



the probably of this newborn being a girl with colour blindness is zero

- (ii) • cannot be determined (1)
 • as there is still a chance that they develop from two eggs with X chromosomes carrying the mutation / only shows the inheritance of one trait, cannot tell if they have the same or different phenotypes in other traits (1)

(2)

11 marks

7. (a) Concept for mark award:
- identify overlapping niches from the information as evidence (1x2)
 - concept of competition resulting from similar ecological niches (1)

(3)

e.g.

Any **two** of the following as evidence:

- both feed on small insects (1)
- they have a similar body size (1)
- there is some degree of overlap in their habitats (1)
- these show that their ecological niches are similar / overlapping, i.e. there may have been keen competition between them (1) therefore the greenhouse frog may threaten the Romer's Tree Frog

(b) Any **one** of the following:

- greenhouse frogs have yet to be found in the natural range of Romer's Tree Frog / the distribution of the two frogs has very little overlap now (1)
- the abundance of the two frogs are not known (1)

(1)

- (c) • record the number of greenhouse frogs and Romer’s Tree Frogs in areas where their habitats overlap over a period of time / put the two frogs in a simulated habitat and record their number over a period of time (1)
 • if the number of greenhouse frogs increases while Romer’s Tree Frog decreases (1) it may imply that the existence of the greenhouse frog has posed a threat to Romer’s Tree Frog (2)

6 marks

8. (a) (i) • sunlight / light energy from the sun / the sun (1)
 (ii) • no sunlight can reach the sea bottom, so there are no photosynthetic producers down there (1)
 • therefore the dead bodies of the whales become an important source of energy / food for the organisms at the bottom of the sea (1)
 (b) • they decompose the organic matter to inorganic matter for the cycling of materials / they are decomposers (1)

- (c) Concept for mark award:
 • quote relevant data with explanation of how it supports the example as ecological succession (1+1) x2 (4)

e.g. (any *two* sets:)

Characteristics of ecological succession	Evidence from the bar chart
dominant species is replaced over time	(any two dominant species with time reference) e.g.: • species P is the dominant species in month 0-12, followed by species R in month 13-36 • species R is the dominant species in month 13-16, and is then replaced by species S in month 37-60+ • species P is the dominant species in the early stage, then is replaced by species R, and species S becomes dominant in the later stage
composition / structure of the community changes with time	(a description showing the change in composition) e.g. • species P and R appear first in month 0-6, later change to species P, Q and R in month 7-12
climax community	• species R, S and T remain stable from month 49 to 60

8 marks

9. (a) (i)
- | Treatment | Deduction |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 versus 2 | • it is shown that achenes are responsible for the enlargement of the strawberry (1) |
| 2 versus 3 | • it is shown that auxin is the plant hormone that causes enlargement of the strawberry (1) |
| 1 versus 3 | • no conclusion / deduction can be reached by comparing the results of set-ups 1 and 3 as there is more than one variable in the two set-ups (1) |
- (3)

		<u>Marks</u>
	(ii) • achenes produce auxins, which cause the enlargement of the strawberry during its development (1)	(1)
	(iii) • it eliminates the individual difference between the strawberries in set-ups 1 and 2 (1)	(1)
	(b) Any <i>one</i> set of the following:	
	• positive phototropic response in shoot (1) to ensure the shoot receives light for photosynthesis (1)	(2)
	• negative phototropic response in root (1) to ensure the root grows into the soil (1)	
		<hr/> 7 marks
10.	(a) • mouth cavity / small intestine (1)	(1)
	(b) (i) $11100 / 2675 \times 250 = 1037.4 \text{ g}$ (1) [no unit no mark]	(1)
	(ii) (1) $11100 / 2675 \times 3.5 = 14.5 \text{ g}$ (1) [no unit no mark]	(1)
	(2) • his blood protein level will be lower than normal people (1) • because his protein intake is much lower than the recommended daily requirement (1)	(2)
	(3) • the low blood protein level leads to a higher water potential than normal at the venous end of the capillary network (1) • the amount of water in tissue fluid returning to the blood at the venous end of the capillary will be reduced (1) hence, tissue fluid will accumulate	(2)
	(c) (i) • inner membrane * / cristae * (1)	(1)
	(ii) • his blood lactate level will increase (1) • as the oxidative phosphorylation is shut down, his body cells will switch to anaerobic respiration to obtain energy / rely on glycolysis for energy release (1) • lactate / lactic acid will be produced in anaerobic respiration (1) and be released into the blood	(3)
		<hr/> 11 marks

11. **Increasing yields:**

- an increase in temperature may speed up the enzymatic or metabolic reactions (1), this leads to an increase in the photosynthesis rate of the crops (1), there is a net production of food or an increase in the overall growth rate of the crops (1)*, leading to more food being stored in the crops or an increase in the overall size of the crops (1)#
- an increase in temperature may speed up bacterial decomposition to increase the supply of inorganic minerals (1), resulting in an increase in the overall growth rate of the crops (1)*, the overall size of the crops increases (1)#

max. 3

Rationale behind the scientists' worry:

- in asexual reproduction, offspring are produced through mitosis (1), so they are genetically identical to the parent plants / have no genetic variations (1)@
- when there is a change in the environment which is unfavourable to the parent plants (1) all offspring will be threatened, with no exception (1)
- micro-organisms / pathogens / pests are more active / reproduce faster at high temperatures (1)
- all offspring will be vulnerable / susceptible to diseases or pest attack (1) as they are genetically identical (1)@

max. 5

*#@ To be awarded once only

Effective communication (0-3)

max.3
11 marks

Mark award for communication:

Mark	Clarity of expression and relevance to the question	Logical and systematic presentation
3	<ul style="list-style-type: none"> • Answers are easy to understand. They are fluent, showing good command of language. • There is no or little irrelevant material. 	<ul style="list-style-type: none"> • Answers are well structured, showing coherence of thought and organisation of ideas.
2	<ul style="list-style-type: none"> • Language used is understandable but there is some inappropriate use of words. • A little irrelevant material is included but does not mar the overall answer. 	<ul style="list-style-type: none"> • Answers are organised, but there is some repetition of ideas.
1	<ul style="list-style-type: none"> • Markers have to use some time and effort in understanding the answer(s). • Irrelevant material obscures some minor ideas. 	<ul style="list-style-type: none"> • Answers are a bit disorganised, but paragraphing is evident. Repetition is noticeable.
0	<ul style="list-style-type: none"> • Language used is incomprehensible. • Irrelevant material buries the major ideas required by the question. 	<ul style="list-style-type: none"> • Ideas are not coherent or systematic. Candidates show no attempt to organise thoughts.

1. (a) (i)

Concept for mark award: <ul style="list-style-type: none">• identify the origin of oestrogen secretion: ovaries / developing follicles (1)• decreased secretion / production of oestrogen (1)• comparison of oestrogen level with normal range (1)

 (3)
- e.g.
- her ovaries may have been damaged by the abdominal injury / the abdominal injury may have affected follicle development in the ovaries / her follicles may be in poor condition after the abdominal injury (1)
 - therefore, the secretion / production of oestrogen by the ovaries / follicles decreased / the ovaries / follicles failed to secrete enough oestrogen (1)
 - as a result, Susan's blood oestrogen level was below the normal range / was lower than normal throughout the cycle (1)
- (ii)

Concept for mark award: <ul style="list-style-type: none">• hormonal interaction: level of oestrogen on the secretion of FSH (1)• pituitary gland secretes more FSH (1)• comparison of FSH level with normal range (1)

 (3)
- e.g.
- Susan's blood oestrogen level was lower than normal, this removed the negative feedback / inhibition on the secretion of FSH from pituitary gland (1)
 - the pituitary gland secretes more FSH (1)
 - as a result, the blood FSH level is always higher than the normal range / was higher than normal range throughout the cycle (1)
- (iii)

Concept for mark award: <ul style="list-style-type: none">• relate the low blood progesterone level to failure to maintain the uterine lining (1)• point out that the uterine lining starts breaking down earlier than normal (1)

 (2)
- e.g.
- Susan's blood progesterone level was too low to maintain the thickness of the uterine lining (1)
 - as a result, the uterine lining kept breaking down at an earlier stage of the menstrual cycle (1) leading to a longer duration of menstrual flow
- (iv)

Concept for mark award: <ul style="list-style-type: none">• correct identification of hormone (1)• LH surge before ovulation (1)

 (2)
- e.g.
- LH (1)
 - there should be a sharp increase / a sudden increase / a sharp rise in LH level just before ovulation (1)

- (b) (i)

<p>Concept for mark award:</p> <ul style="list-style-type: none"> • concept of heat balance (1) • correct receptor + correct stimulus (1) • correct coordinating centre + correct response of nerve signal (1) • correct effector + correct response (1)

 (4)
- e.g.
- body may gain heat from the environment when the room temperature (i.e. 38 °C) is higher than the body temperature / the body continues to produce heat but the heat loss to the surroundings is ineffective as the room temperature is higher (1)
 - thermoreceptors in the hypothalamus / skin detect the increase in body temperature (1)
 - heat loss centre in the hypothalamus is stimulated to send out more nerve impulses (1)
 - to the arterioles near the skin surface, causing them to dilate (1), as a result, more blood flows to the skin surface to promote heat loss
- (ii) (1)

<p>Concept for mark award:</p> <ul style="list-style-type: none"> • identify the trend in relative amount of skin blood flow (1) • the inference from the trend about the condition of the arteriole (1)

 (2)
- e.g.
- the relative amount of skin blood flow decreased when the body temperature of the exercise group increased from 36°C to 37°C (1)
 - this indicates that the arterioles leading to the skin surface were constricting / undergoing vasoconstriction / the diameter of the arterioles leading to skin was becoming narrower (1)
- (2)

<p>Concept for mark award:</p> <ul style="list-style-type: none"> • redistribution of blood during exercise (1) • significance of such redistribution (1)

 (2)
- there was a redistribution of blood with more blood flow to the leg muscles (1)
 - to provide more oxygen and nutrients for respiration to release energy (1) to support muscle contraction for running
- (iii) Any *two* of the following:
- skin flow starts to rise / vasodilation begins at a higher temperature in the exercise group / the temperature set-point for the exercise group relative to the resting group is higher (1)
 - skin blood flow in the exercise group levelled off at a lower amount of skin blood flow (1)
 - skin blood flow in the exercise group started to level off at a higher body temperature (1)
 - skin blood flow in the exercise group is lower at all body temperatures (1)

20 marks

- 2 (a) (i)

Concept for mark award: <ul style="list-style-type: none">• identification of the trend in Graph I (1) and how it relates to accumulation with increased exposure time (1)• identification of the trend in Graph II (1) and how it relates to accumulation through increasing amount of seafood consumption (1)

 (4)

e.g.

- the milk collected from older women has a higher concentration of pollutant X (1), showing that pollutant X has accumulated in the body over time (1)
- the milk collected from women with a higher frequency of seafood consumption has a higher concentration of pollutant X (1), showing that pollutant X has accumulated after eating more seafood (1)

- (ii) (1)
 - fat-soluble (1)
 - cannot be degraded / metabolised / broken down easily (1)
 - cannot be excreted easily (1) (3)

- (2)

Concept for mark award: <ul style="list-style-type: none">• relate the fat content of the milk to fat-soluble property (1)• relate milk being a metabolite produced by the body (1)

 (2)

e.g.

- milk contains fat, so a fat-soluble pollutant can be found in it (1)
- milk is produced by the mammary gland / the body, the presence of pollutant in it shows that it has been found inside the body cells (1)

- (iii) e.g.
 - pesticides sprayed on farmland being washed into rivers and sea (1)
 - discharge of pollutants from factories into rivers and sea (1) (2)

- (b) (i)

Concept for mark award: <ul style="list-style-type: none">• comparison of the results of two treatments (1) + correct conclusion (1) x 2

 (4)

e.g.

Comparison of the results of two treatments	Deductions
the number of invertebrate species found on the flat tiles / treatment 2 was higher than on the seawall surface / in treatment 1 (1)	the tile itself / the material of the tiles can increase the species richness of invertebrate species / the number of invertebrate species (1)
the number of invertebrate species found on the tiles with crevices / treatment 3/4 was higher than on the flat surface / in treatment 2 (1)	the presence of crevices can increase the species richness of invertebrate species / the number of invertebrate species (1)
the number of invertebrate species found on tiles with crevices of 5 cm depth / treatment 4 was higher than on tiles with crevices of 2.5 cm / in treatment 3 (1)	the greater the depth of the crevices, the higher the species richness of invertebrate species / the number of invertebrate species (1)

Marks

- (ii)

Concept for mark award: <ul style="list-style-type: none">elaborate on how the crevices help the organisms to cope with the challenge (1) x 2	(2)
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- (1) e.g. any *one* of the following:
- provide shaded areas / hiding places where the temperature will be lower / there is water trapped in the crevices, keeping the temperature of the tile low (1)
 - sea water is trapped inside the crevices during low tides, preventing the area from drying up / preventing desiccation (1)
 - provides hiding places for organisms, to protect them from predators (1)
- (2) e.g. any *one* of the following:
- crevices provide hiding places for organisms, preventing them from being washed away by waves (1)
 - crevices provide surfaces for sessile organisms to attach onto so that they are not washed away by waves (1)
- (iii) (1) the abundance of individual species (1) / the number of individuals of each species (1) (1)
- (2)
 - number of species / species richness increases after installation (1)
 - the abundance of individual species is relatively even (1) (2)

20 marks

Paper 2 Section C

Marks

3. (a) (i)

Concept for mark award: <ul style="list-style-type: none">relate the risk of contamination to food processing of mince beef (1x2)	(2)
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- e.g. any *two* of the following:
- grinding / chopping of meat into pieces increases the exposed surface area, increasing the risk of microbial contamination (1)
 - during mixing, the microbes are spread throughout, so will be present inside and out (1)
 - more food processing steps are involved in producing mince beef, so the risk of contamination from food handlers / processing environment / processing tools is higher (1)

(ii) (1)

	Bacterium X		Bacterium Y	
	5°C	20°C	5°C	20°C
Mean time (hr)	32.50	10.58	57.65	10.77

 (2)

- (2)

Concept for mark award: <ul style="list-style-type: none">correct comparison of bacterial growth rate at each temperature (1x2)	(2)
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- e.g.
- bacterium X has a faster growth than bacterium Y rate at 5°C (1) or vice versa
 - the growth rates of bacterium X and bacterium Y are more or less the same at 20°C / the difference in the growth rates of bacterium X and bacterium Y at 20°C is insignificant (1)

- (3)

Concept for mark award: <ul style="list-style-type: none"> • correct identification of bacterium X (1) • relate the temperature of refrigeration to the faster growth rate of bacterium X (1) • how it leads to food spoilage (1) 	(3)
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- bacterium X (1)
 - refrigerators normally have a storage temperature of 4°C / close to 5°C as in the experiment, which is more favourable for the growth of bacterium X (1)
 - bacterium X multiplies / reproduces / duplicates / grows to a large population even in the refrigerated condition, leading to food spoilage in a shorter time (1) than bacterium Y
- (4) the presence of bacterium Y indicates: (any *two* of the following)
- possible contamination from food handlers with unwashed hands / unclean hands / poor personal hygiene (1)
 - the possibility that the environment / tools for food processing have been contaminated (1)
 - there is cross-contamination between the meat and animal intestines / intestinal content during slaughtering (1)
- (b) (i) during the stationary phase,
- the rate of cell formation is equal to the rate of cell death (1)
 - there is no net increase or decrease in the number of living cells / the number of living cells remains relatively stable (1)
- (ii)

Concept for mark award: <ul style="list-style-type: none"> • the limitations of optical density measurement (1) • relate the characteristics of the stationary phase to the expected change in the optical density (1) 	(3)
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- optical density measures both living and dead cells / cannot distinguish between living and dead cells (1)
- (either *one* of the following sets)
- during the stationary phase, new cells are still being formed (1), i.e. the total number of cells keeps increasing, therefore there should be an increase in the optical density / turbidity during the stationary phase / period CD (1)
 - as the optical density / turbidity remained unchanged in period DE (1), this implies that there is no more production of new cells (1), i.e. DE should be the lag phase instead of stationary phase
- (iii) the optical density method relies on the amount of light scattered by the bacterial cells / transmitted through the bacterial culture (1)
- Any *one* of the following:
- some cells may settle down at the bottom of the culture, so the measured value will be lowered (1)
 - some cells may form clumps / films on the surface, so the measured value will be lowered (1)
 - to ensure the cells are evenly distributed such that the measurement truly reflects the number of cells in the culture (1)
- (iv) (1) • P, R, S, Q (1) (1)
- (2) • 64 µg mL⁻¹ (1), no unit no mark (1)

20 marks

4. (a) (i)

Concept for mark award: <ul style="list-style-type: none">• correct identification of restriction enzymes (1)• concept of sticky end (1)• concept of complementary base pairing (1)

 (3)
- e.g.
 - restriction enzymes P and R (1)Either **one** of the following sets:
 - Restriction enzyme P cuts the plasmid to produce a sticky end which is complementary to the sticky end on the left hand side of the DNA fragment (1)
 - Restriction enzyme R cuts the plasmid to produce a sticky end which is complementary to the sticky end on the right hand side of the DNA fragment (1)Or
 - they cut the plasmid to produce sticky ends (1)
 - which are complementary to the sticky ends found on the given DNA fragment to be inserted (1)
- (ii)

Concept for mark award: <ul style="list-style-type: none">• the purpose of step IV (1)• how the purpose is fulfilled (1)

 (2)
- to screen out bacteria which have taken up plasmid A (1)
 - because plasmid A contains the ampicillin resistant gene which enables the bacteria with plasmid A to survive in the presence of ampicillin (1)
- (iii) (1)

Concept for mark award: <ul style="list-style-type: none">• insertion efficiency (not 100% of plasmid A has been inserted with the DNA fragment containing the <i>GFP</i> gene) (1)• expression of the <i>GFP</i> gene results in production of green fluorescent proteins which emit green light / glow under UV illumination (2)

 (3)
- e.g.
 - bacterial cells on the agar plate have taken up plasmid A but only some of the plasmid A were inserted with *GFP* gene / some of the plasmid A has not taken up the *GFP* gene / some of the plasmid A has self-ligation, i.e. there is no insertion of *GFP* gene (1)
 - only those bacterial cells which have taken up plasmid A with successful insertion of *GFP* gene can produce the green fluorescent protein (1)
 - as a result, these bacterial colonies / bacteria with green fluorescent protein will glow under UV (1)
- (2) Any **one** of the following:
 - as a marker to show if the transformed cells have taken up the target gene (1)
 - as a tag to trace the expression of certain genes (1)
 - produce transgenic pets that glow under UV (1)
- (b) (i) • plant tissue culture / micropropagation (1) (1)
- (ii) (1) • W, X and Z (1) (1)

Marks

- (2)

Concept for mark award:
• inference of the absence of a DNA band in Y in Gel I (1)
• implication of the interpretation of the results in Y in Gel II (1)

 (2)
- the absence of the DNA band in Y in Gel I indicates that no *ACTIN* gene is detected, i.e. probably because the DNA extraction from Y was unsuccessful / PCR on DNA samples from Y were unsuccessful / the sample does not contain rice DNA (1)
 - hence, the result of sample Y in Gel II should not be interpreted as the absence of *HR* gene / we cannot confirm if the negative result of sample Y in Gel II is true or not (1)
- (iii) (1) • group 2 (1)
- it shows the largest number of leaves without herbicide damage / smallest leaf area with injury / with least leaf injury among the groups (1) (2)
- (2) • sample Y (1)
- group 1 has the highest degree of herbicide damage in its leaves, i.e. with the least resistance to herbicides (1) (3)
 - sample Y has no *HR* gene so it should be the one with least herbicide resistance among the four rice lines (1)
- (3) • there may be multiple insertions of *HR* genes, resulting in higher herbicide resistance in some samples (1)
- the insertion of the *HR* gene may not necessarily result in gene expression in the GM plant (1) (2)

20 marks