HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2023

BIOLOGY PAPER 2

11:45 am – 12:45 pm (1 hour)
This paper must be answered in English

INSTRUCTIONS

(1) There are **FOUR** sections, A, B, C and D in this Paper. Attempt **ALL** questions in any **TWO** sections.

(2) Write your answers in the Answer Book DSE (C) provided. Start each question (not part of a question) on a new page.

(3) Present your answers in paragraphs wherever appropriate.

(4) Illustrate your answers with diagrams wherever appropriate.

(5) The diagrams in this paper are **NOT** necessarily drawn to scale.

Not to be taken away before the end of the examination session

SECTION A **Human Physiology: Regulation and Control**

Answer **ALL** parts of the question.

1(a) Susan is a healthy young woman who got an abdominal injury in a traffic accident months ago. Since then, her menstrual flow lasted much longer than her usual period. Her doctor arranged blood tests to check her hormone levels during a menstrual cycle. The results are shown below:

Name: Susan Sex: Female Age: 27

28-day menstrual cycle	Hormone	Level	Normal Range
Days 1-11	Oestrogen	34.3	125.9-661.2
	Follicle stimulating hormone (FSH)	31.7	4.3-7.1
	Progesterone	0.6	0.6-1.0
Days 12-16	Oestrogen	138.1	320.6-914.8
	Follicle stimulating hormone (FSH)	38.5	5.3-11.5
	Progesterone	1.5	2.6-5.1
Days 17-28	Oestrogen	92.3	151.2-552.8
	Follicle stimulating hormone (FSH)	22.3	2.4-6.2
	Progesterone	6.8	9.5-40.3

* All values are expressed in arbitrary units.

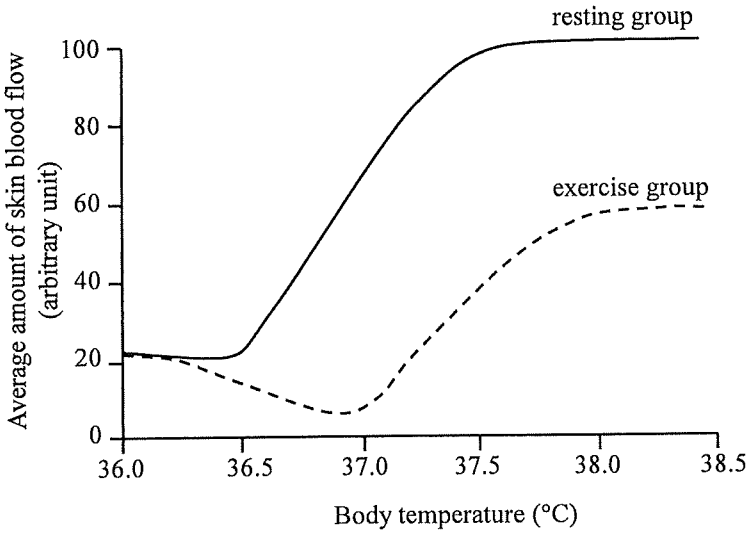
(i) With reference to the secretion of oestrogen, which part of Susan's reproductive system could have been affected after the abdominal injury? Explain how this would lead to the oestrogen levels shown in her blood test results. (3 marks)

(ii) With reference to the interaction between oestrogen and FSH, explain the overall result of the FSH levels in Susan's blood tests. (3 marks)

(iii) Before the accident, Susan's menstrual flow lasted for only four to five days. After the accident, her menstrual flow lasted much longer. With reference to the above results, suggest an explanation to account for this phenomenon. (2 marks)

(iv) To check if there is ovulation in Susan's menstrual cycle, the level of which hormone should be measured? What is the expected change for the level of this hormone if there is ovulation? (2 marks)

1(b) In a study of the effect of exercise on thermoregulatory response in a hot environment, two groups of healthy volunteers stayed in a room at 38 °C and 50% relative humidity. One group was kept at rest while the other group was asked to run on treadmills set at a constant speed of 5 km hr^{-1} for 45 minutes. The skin blood flow in the legs and body temperature of the volunteers were continuously monitored throughout the experiment. The relationship between these two parameters is shown in the graph below:



(i) Explain why there was an increase in blood flow to the skin of the resting group. (4 marks)

(ii) (1) With reference to the curve of the exercise group, deduce the condition of the arterioles leading to the skin surface when the body temperature increased from 36°C to 37°C. (2 marks)

(2) What is the significance of such change to the exercise group? (2 marks)

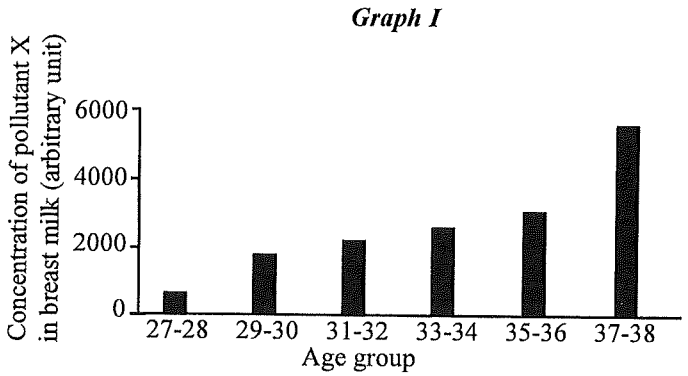
(iii) Apart from the change in (ii), state ***two*** other differences in the thermoregulatory response of skin blood flow between the two groups. (2 marks)

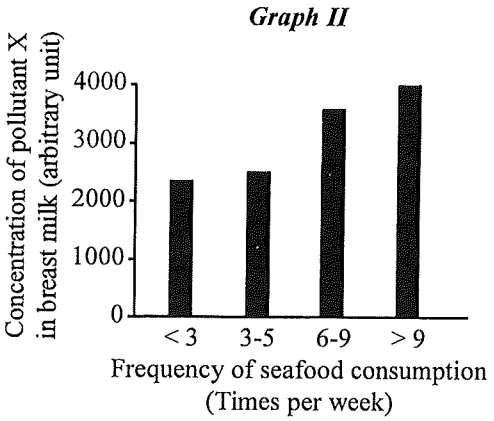
Go on to the next page

SECTION B Applied Ecology

Answer **ALL** parts of the question.

2(a) In 2000, a survey was conducted in Hong Kong to assess the bioaccumulation of pollutant X in the human body. In the survey, human breast milk samples were collected for analysis. A questionnaire was prepared to obtain information of the participants such as age, dietary intake and health condition. The graphs below show the concentration of pollutant X in the breast milk collected in relation to the age groups (Graph I) and the frequency of sea food consumption per week (Graph II).





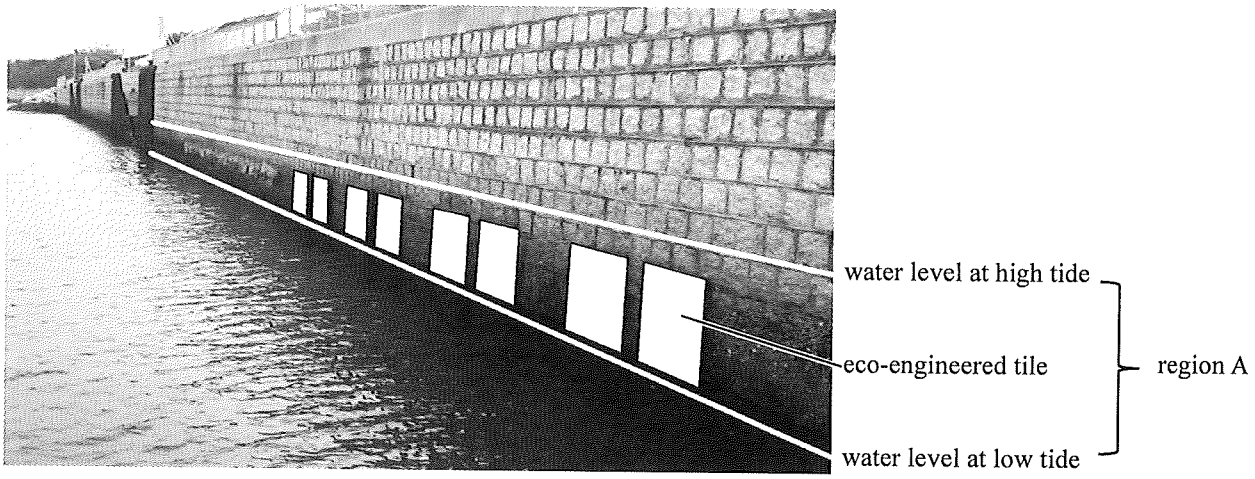
(i) With reference to the above graphs, give ***two*** pieces of evidence which support that pollutant X can be accumulated in the human body. Explain your answer. (4 marks)

(ii) (1) List ***three*** common properties of the pollutants which will lead to bioaccumulation. (3 marks)

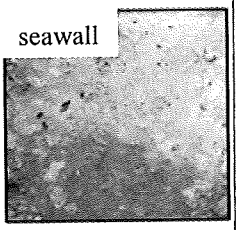
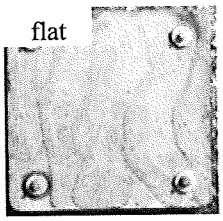
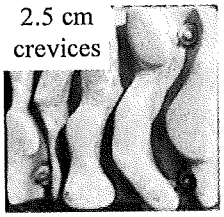
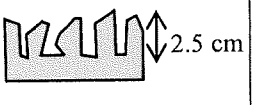
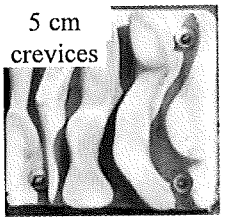
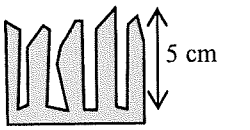
(2) Suggest why milk could be used as one of the indicators for bioaccumulation. (2 marks)

(iii) With reference to the above case, suggest ***two*** human activities which would lead to the release of bioaccumulative pollutants to the environment. (2 marks)

2(b) Eco-engineered tiles were installed on a local seawall in an attempt to increase the biodiversity of the shoreline. The photograph below shows a seawall where eco-engineered tiles are installed:



An experiment was conducted with the installation of different eco-engineered tiles on a local seawall. The table below shows four treatments and the number of invertebrate species living on each surface after 12 months:

Treatment	Surface View	Side View	Number of invertebrate species found on the surface
(1) Original seawall surface		---	4
(2) Tiles with flat surface installed on the seawall			8
(3) Tiles with crevices of 2.5 cm depth installed on the seawall			13
(4) Tiles with crevices of 5 cm depth installed on the seawall			17

(i) By comparing relevant treatments, deduce ***two*** effects of installing the eco-engineered tiles. Tabulate your answer in the answer book according to the following format. (4 marks)

Comparison of the results of two treatments	Deduction

(ii) Suggest how the crevices of the eco-engineered tiles could help organisms in Region A to cope with threats posed by the following environmental conditions:

(1) exposed seawall surface during low tide (1 mark)

(2) wave action (1 mark)

(iii) (1) Suggest another group of data which should be collected to assess the effect of installing eco-engineered tiles on the biodiversity in Region A. (1 mark)

(2) To confirm if the installation of eco-engineered tiles has increased the biodiversity of Region A, all the data collected should fulfil certain requirements. List these requirements. (2 marks)

Go on to the next page

SECTION C Microorganisms and Humans

Answer **ALL** parts of the question.

3(a) Microbial contaminations happen during food processing if the food is not properly handled. The photographs below show two meat products: minced beef and steak.

Minced beef

Steak

(i) Suggest why minced beef is more susceptible to microbial contamination than steak. (2 marks)

(ii) To assess the safety and quality of minced beef, four minced beef samples were collected for microbial analysis. The samples were incubated at two different temperatures (5°C and 20°C). At regular time intervals, samples were plated for colony count of bacterium X and bacterium Y respectively. The time taken for the colony count to increase 10-fold were recorded. The results are shown in the table below:

Sample	Time taken for the colony counts to increase 10-fold (hour)			
	Bacterium X		Bacterium Y	
	5°C	20°C	5°C	20°C
1	34.95	8.93	79.78	7.28
2	41.51	7.74	65.83	8.47
3	32.86	11.60	44.60	9.65
4	20.69	14.03	40.39	17.66

(1) Calculate the mean time taken for the colony count to increase 10-fold for bacterium X and bacterium Y at 5°C and 20°C. Tabulate your results in the answer book according to the following format. (2 marks)

	Bacterium X		Bacterium Y	
	5°C	20°C	5°C	20°C
Mean time (hour)				

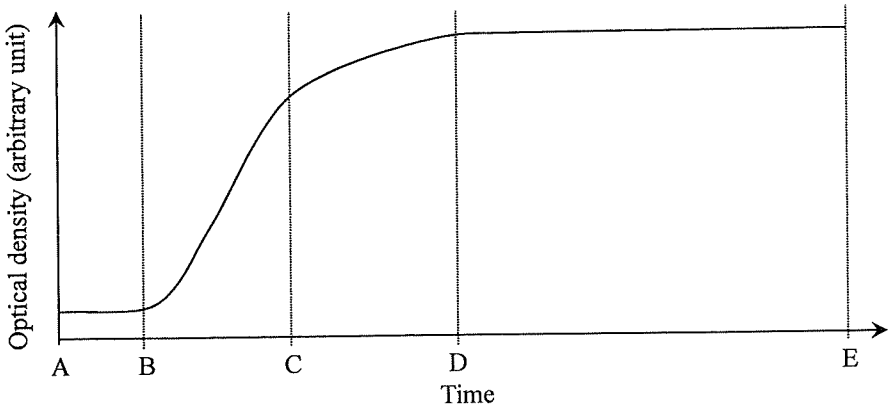
(2) Compare the growth rates of bacteria X and Y at different temperatures. (2 marks)

(3) According to the answer in (2), which bacterium is more likely to cause food spoilage of the samples stored in the refrigerator? Explain your answer. (3 marks)

(4) Bacterium Y is commonly found in the intestinal tract of animals. Explain why bacterium Y is often used as an indicator of microbial contamination of meat during food processing. (2 marks)

3(b) The growth of a bacterial culture was monitored by measuring the turbidity of the culture in terms of optical density. The results are shown in the Graph I below:

Graph I



(i) What are the characteristics of the stationary phase of bacterial growth? (2 marks)

(ii) With reference to the principle of optical density measurement, explain why CD is the stationary phase instead of DE with supporting evidence from the graph. (3 marks)

(iii) With reference to the principle of optical density measurement, explain why the bacterial culture should be mixed well before measuring the optical density. (2 marks)

(iv) *Pseudomonas aeruginosa* is a bacterial species with resistance to a number of antibiotics. It causes serious infections in hospital patients with weak immune systems.

To assess the effectiveness of different antibiotics in treating patients infected with *P. aeruginosa*, *P. aeruginosa* was isolated from the patients to prepare a culture. A fixed amount of the culture was added to mini-wells containing equal volume of antibiotics at different concentrations for incubation as shown in Diagram II. The results after incubation are shown in Diagram III:

Diagram II (3D view)

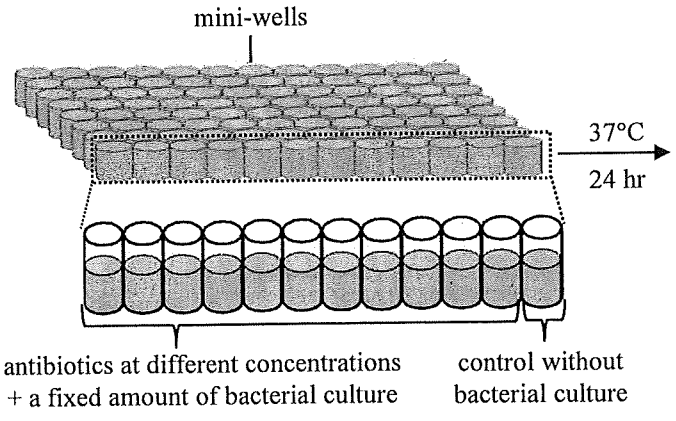
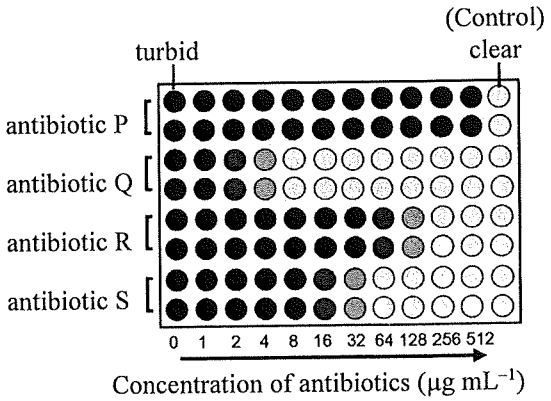


Diagram III (top view)



(1) Arrange the antibiotics in ascending order of their effectiveness in treating patients infected with *P. aeruginosa*. (1 mark)

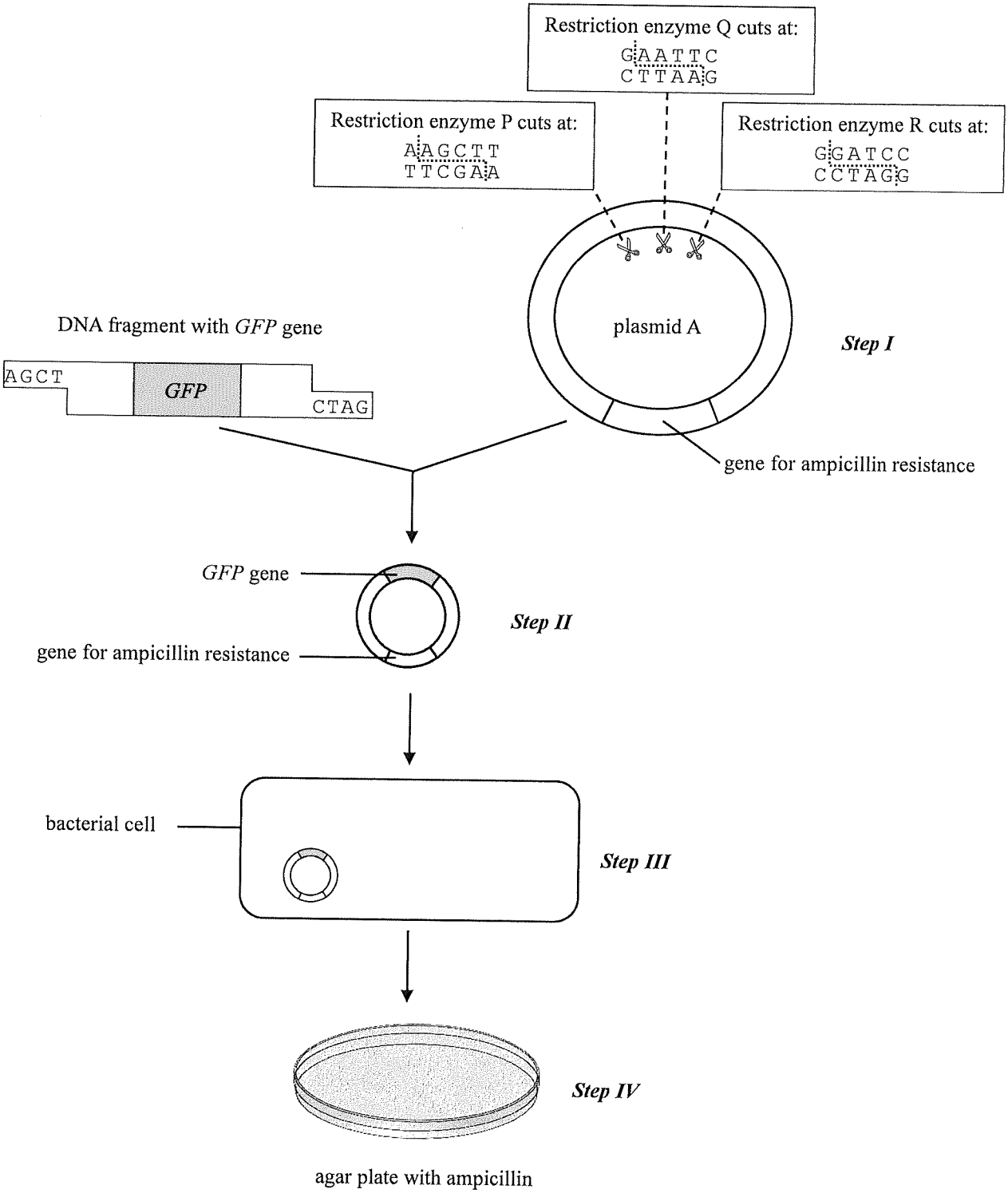
(2) What is the minimum concentration of antibiotic S required to treat the patients effectively? (1 mark)

Go on to the next page

SECTION D Biotechnology

Answer **ALL** parts of the question.

4(a) *GFP* gene encodes a protein known as Green Fluorescent Protein (GFP) which naturally occurs in some jellyfish. This GFP emits green fluorescence when exposed to ultra-violet (UV) light. The diagram below shows the workflow of the insertion of the *GFP* gene into plasmid A and its transformation of bacterial cells:

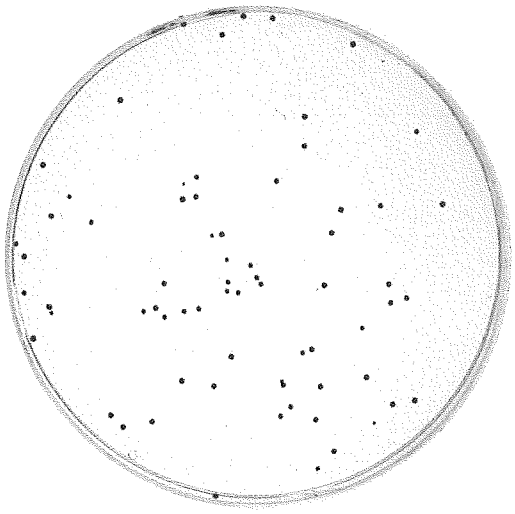


(i) State the restriction enzymes to be used for the insertion of the *GFP* gene into plasmid A. Explain your answer. (3 marks)

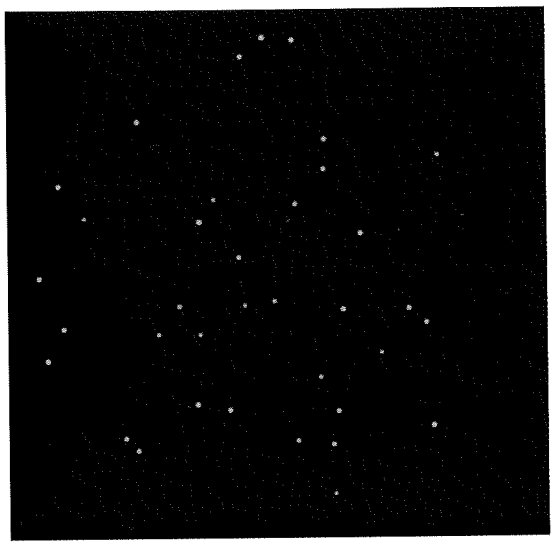
(ii) What is the purpose of Step IV? How can this step achieve its purpose? (2 marks)

(iii) The diagrams below show the appearance of bacterial colonies on the agar plate under normal light and UV light:

Under normal light



Under UV light

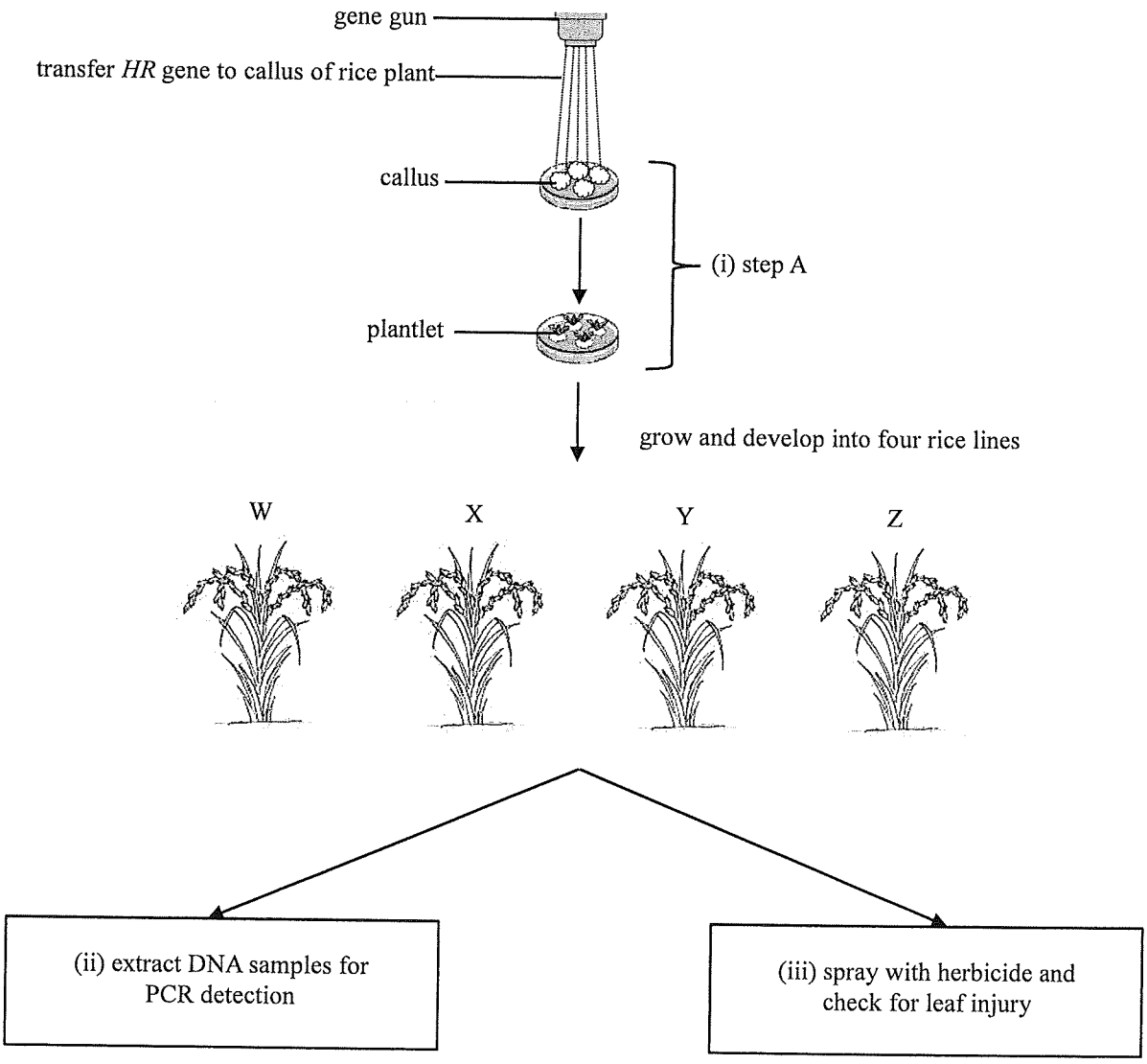


(1) Explain why only some bacterial colonies glow under UV light. (3 marks)

(2) Suggest ***one*** application of *GFP* gene. (1 mark)

Go on to the next page

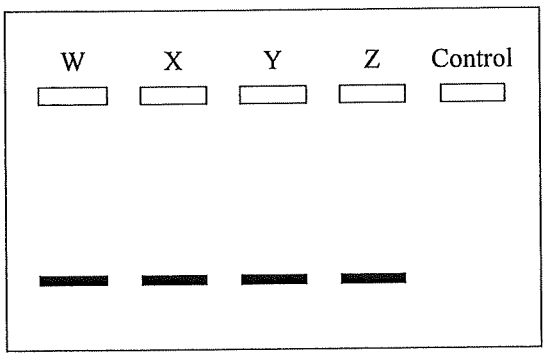
4(b) A company developed genetically modified (GM) rice plants with a herbicide resistant (*HR*) gene using the method shown below:



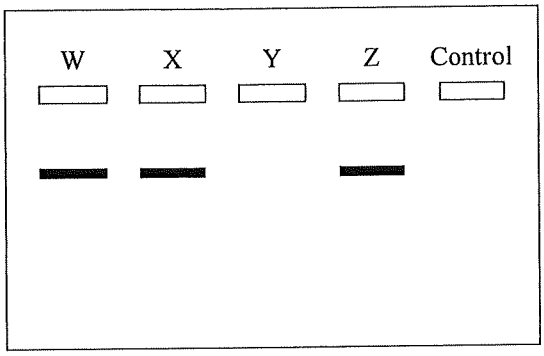
(i) State the technique used in step A. (1 mark)

(ii) PCR was performed on DNA samples of the rice lines W, X, Y and Z to detect the presence of the *ACTIN* gene which is found in all rice plants and the inserted *HR* gene. After completion, the PCR products were subject to gel electrophoresis. For the control, an equal volume of water was used in place of the DNA products. Results of the gel electrophoresis are shown below:

Gel I: PCR detection for *ACTIN* gene



Gel II: PCR detection for *HR* gene



(1) Determine which rice line samples contain the *HR* gene. (1 mark)

(2) If the DNA band in sample Y is absent in Gel I, how would you interpret the result for sample Y in Gel II? (2 marks)

(iii) Four groups (1 to 4) of rice plants were sprayed with a large amount of herbicide. Afterwards, the plants were grown under constant environmental conditions. After two weeks, the number of leaves with different degree of visible injury were recorded by scoring a total of 100 leaves in each group. A summary of herbicide induced injury in the GM rice lines is shown below.

Leaf area with visible injury (%)	Number of leaves			
	Group 1	Group 2	Group 3	Group 4
0	20	90	36	82
1 - 20	16	10	28	10
21 - 50	24	0	15	8
51 - 80	25	0	8	0
81 - 100	15	0	13	0

(1) Which group of rice plants shows the highest herbicide resistance? Explain your answer. (2 marks)

(2) Which rice line sample(s), W, X, Y or Z, is most likely to be represented by Group 1? Explain your answer. (3 marks)

(3) Despite the fact that there is more than one rice line with successful insertion of the *HR* gene, the results of herbicide induced injury still vary a lot. Suggest why this is so. (2 marks)

END OF PAPER

Sources of materials used in this paper will be acknowledged in the *HKDSE Question Papers* booklet published by the Hong Kong Examinations and Assessment Authority at a later stage.