HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2020

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)   In a study, the plasma antidiuretic hormone (ADH) level and plasma sodium ion level of two groups of individuals were compared. They were healthy individuals and patients with disorders of the pituitary gland. The graph below shows the relationship between the levels of the two substances in their bodies:
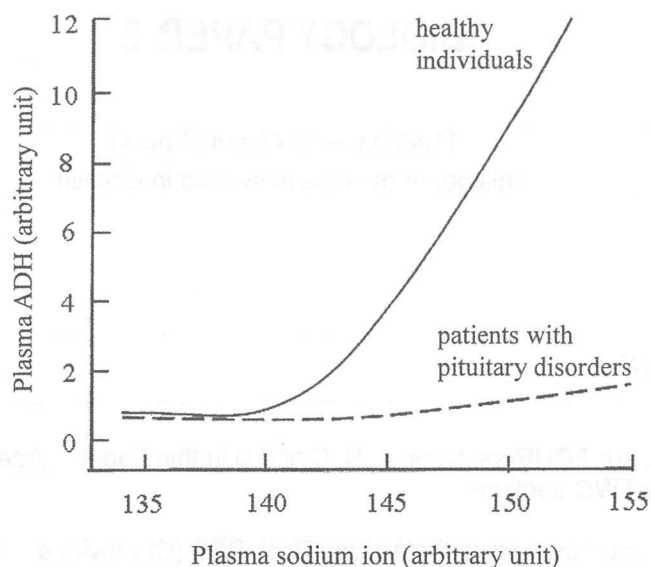
(i)   With reference to the above graph, describe the change in the plasma ADH level in these two groups of individuals.   (3 marks)

(ii)   According to your answer in (a) (i), explain how the volume and concentration of urine produced by the patients would be different from that produced by healthy individuals.   (3 marks)

(iii)   Explain how the increase in plasma sodium ion level leads to changes in plasma ADH level in healthy individuals.   (3 marks)

(iv)   Some female patients with pituitary disorders do not menstruate. Based on your knowledge of the function of the pituitary gland, propose a possible explanation for this phenomenon.   (3 marks)

1(b) In an investigation, a volunteer stayed at rest and breathed in air containing different concentrations of carbon dioxide. Some parameters related to breathing were measured. The results are shown in the table below:

| Concentration of carbon dioxide in the inspired air (%)	Breathing rate (min^{-1})	Breathing depth (L)	Ventilation rate (L min^{-1})
0.04	14	0.5	7.0
0.80	14	0.6	8.4
1.50	14	0.8	11.2
2.70	14	1.2	16.8
3.50	15	1.6	24.0
4.30	17	1.7	28.9
5.60	24	1.7	40.8
6.50	29	1.7	49.3

(i) State the parameter which contributed most to the change in ventilation rate in different ranges of carbon dioxide concentrations. (2 marks)

(ii) Suggest why the breathing depth remained steady as the carbon dioxide concentration exceeded 4.3%. (1 mark)

(iii) Describe the effect of an increase in carbon dioxide concentration on the volunteer's ventilation rate. (1 mark)

(iv) Explain how the increased concentration of carbon dioxide led to a change in the ventilation rate. (4 marks)

SECTION B   Applied Ecology

Answer **ALL** parts of the question.

2(a)   A study was conducted on beaches A and B to investigate the effect of clam harvesting on the animal community on sandy shores. On beach A, clam harvesting was forbidden all year round. On beach B, clam harvesting was allowed from June to September. Field sampling was conducted on both beaches on May 31 and October 1. Animals in the sediment were identified and counted.

(i)   The diagram below shows the number of clams collected from the two beaches on May 31 and October 1:
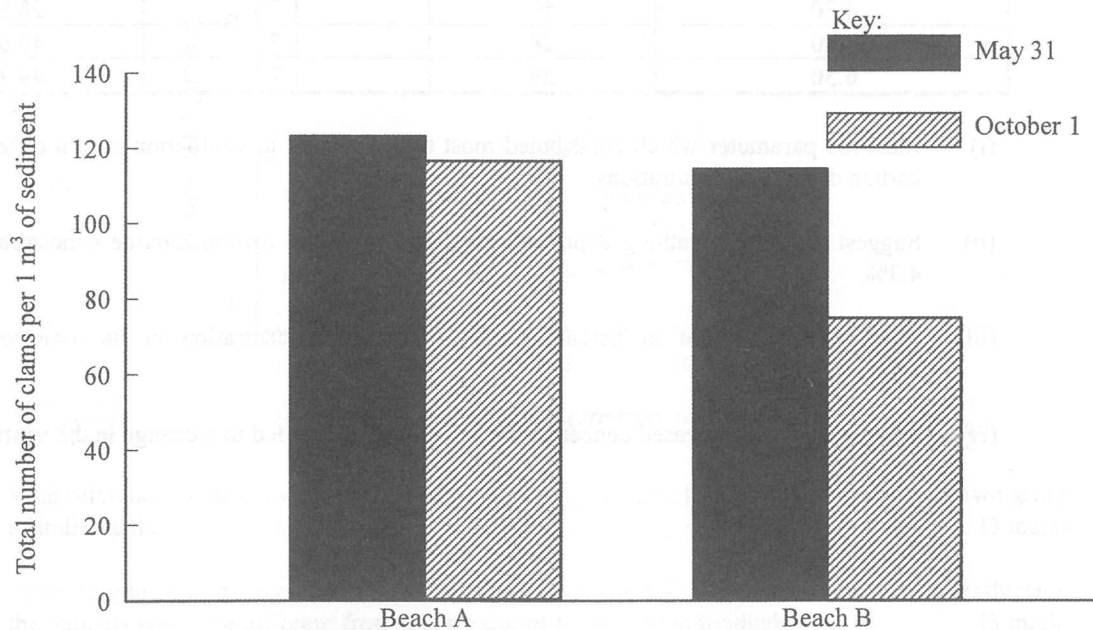
Describe the change in the density of clams on the two beaches.   (2 marks)

(ii)   The table below shows the animal species composition of beaches A and B on May 31 and October 1 (the data on clams are excluded):

	Animal species	May 31		October 1	
		No. of individuals per 1 m³ of sediment	Percentage of total individuals	No. of individuals per 1 m³ of sediment	Percentage of total individuals
Beach A	Species 1	20	31.3	19	30.2
	Species 2	15	23.4	16	25.4
	Species 3	8	12.5	8	12.7
	Species 4	21	32.8	20	30.7
Beach B	Species 1	19	30.6	7	20.6
	Species 2	16	25.8	5	14.7
	Species 3	7	11.3	21	61.8
	Species 4	20	32.3	1	2.9

Based on the results in (a) (i) and (a) (ii), deduce the effect of clam harvesting on the species diversity of the animal community on sandy shores.   (4 marks)

(iii)   The World Wildlife Fund Hong Kong has developed a Clam Gauge as a guideline for harvesting clams. The gauge for a particular calm is shown below:
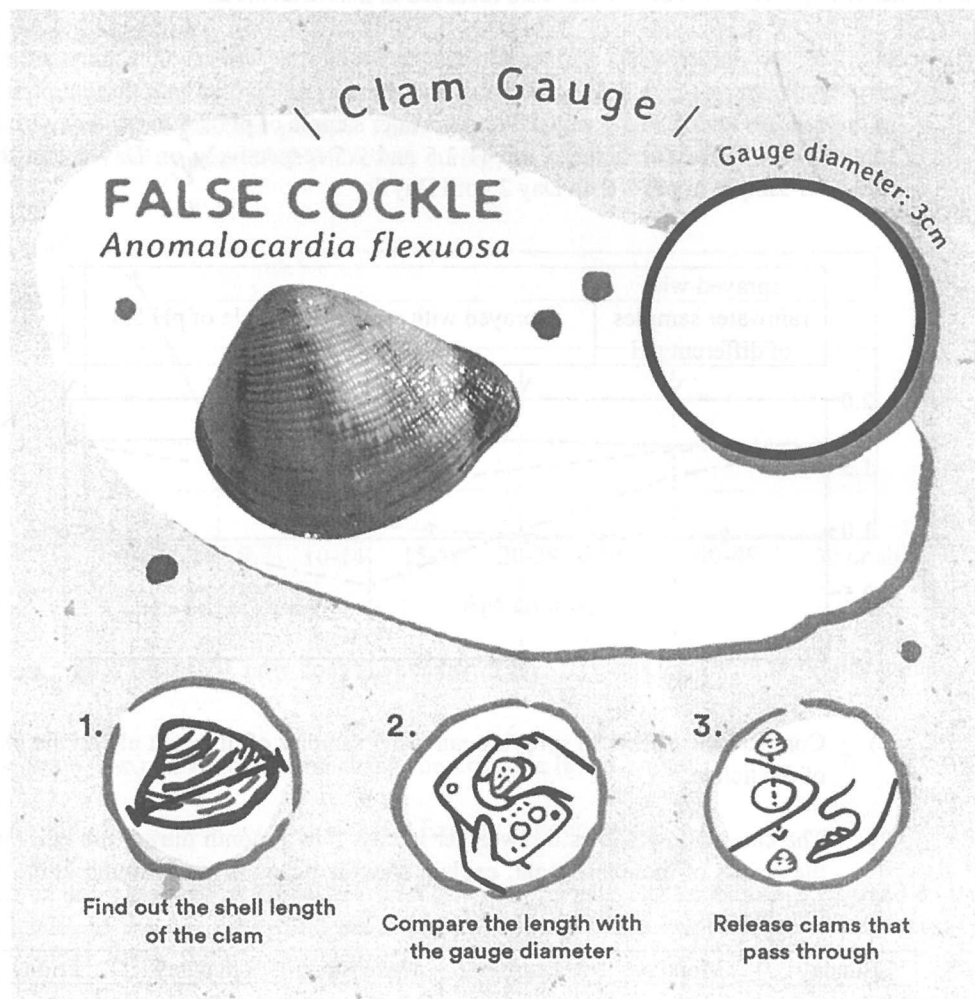
Explain how we can help conserve the clam community by harvesting only clams which cannot pass through the gauge.   (3 marks)

2(b) Normal rainwater has a pH of around 5.6. Acid rain was first noted in the 17th century. At that time, rainwater with pH readings below 2.5 were recorded in industrial areas.

(i) In 1986, an experiment was conducted to study the effect of acidity of rainwater on the photosynthetic rate of a lichen species. The lichens were divided into three groups: Group A served as the control, which was sprayed with rainwater sample of pH 5.6 every day; Groups B and C were sprayed with rainwater samples of pH 3.5 and 2.5 respectively on Day 1 and then sprayed with rainwater sample of pH 5.6 on Day 2 until Day 5.
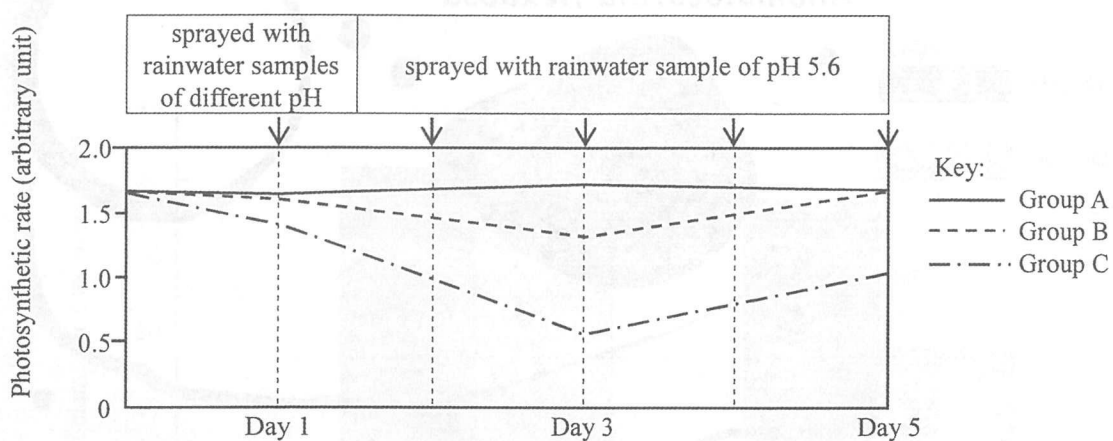
(1) Compare the effects of spraying rainwater samples of different pH on the photosynthetic rate of the lichen.   (4 marks)

(2) The chart below shows the weather in city Y in a month during the rainy season. Based on the results of the experiment, explain why the lichen is rarely found in the industrial area of city Y.   (3 marks)


(ii) State *two* major air pollutants and describe how they cause the formation of acid rain.   (2 marks)

(iii) State *two* effects of acid rain on soil minerals.   (2 marks)

SECTION C　Microorganisms and Humans

Answer **ALL** parts of the question.

3(a)　Hand-foot-and-mouth disease (HFMD) is a viral infection which is transmitted through contact with the stool or secretions of an infected person. There was an outbreak of HFMD in Hong Kong in 2008. The graph below shows the number of HFMD cases during the outbreak:
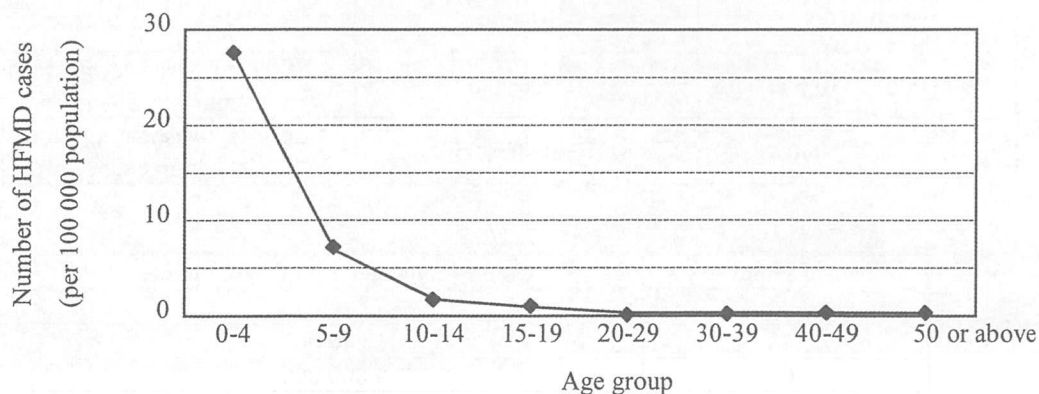
(i)　In age groups below 20, how does the number of HFMD cases vary with the age of patients?

(2 marks)

(ii)　Suggest *two* explanations for the change described in (a) (i).

(2 marks)

(iii)　Can antibiotics effectively treat HFMD? Explain your answer.

(2 marks)

(iv)　One of the symptoms of HFMD is the formation of blisters in the mouth cavity, and on the palms and soles of the feet. The fluid inside the blisters contains a large number of viral particles. The photograph below shows some blisters on a finger:
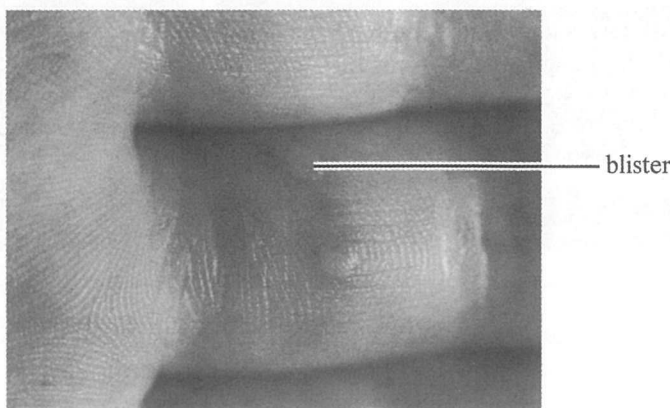
With reference to the life cycle of viruses, describe how a large number of viral particles forms inside the blister.

(4 marks)

3(b) The Centre for Food Safety has established guidelines for assessing the safety and quality of some ready-to-eat food items. One of the assessments involves estimating the bacterial colonies formed per 1 gram of food sample. Table 1 shows the categories of food quality according to the guidelines and Table 2 presents the results of the colony count in sushi samples collected from local restaurants.
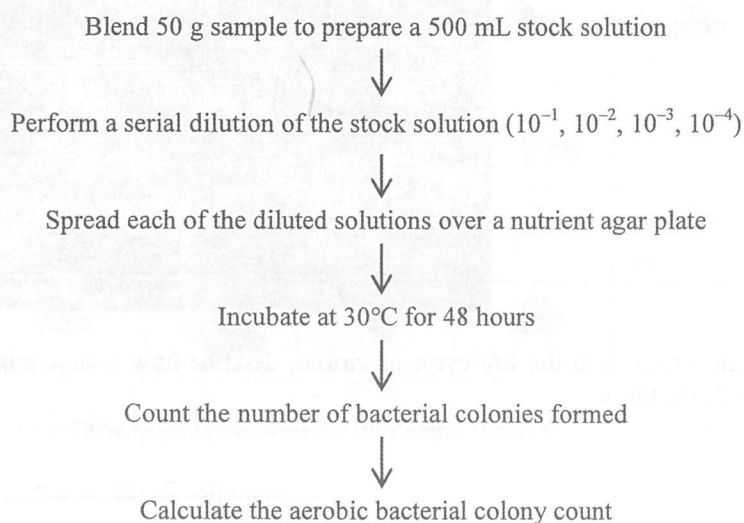
Table 1

| Colony count per 1 g of food sample	Category of food quality	Recommendations
<1 000 000	Satisfactory	No actions to take
1 000 000 – <10 000 000	Borderline	Still considered acceptable for human consumption
≥ 10 000 000	Unsatisfactory	Consider investigating causes for high count

Table 2

Sushi samples	Colony count per 1 g of food sample
A	610 000
B	11 240 000
C	9 800 000
D	16 000 000
E	140 000

(i) List the sushi samples which are unsatisfactory in terms of food quality according to the guidelines from the Centre for Food Safety. (1 mark)

(ii) Even though the food quality of some sushi samples is unsatisfactory, consumption of these sushi samples will not necessarily result in food poisoning or infection. What is the limitation of using bacterial colony count as an indication of food safety? (1 mark)

(iii) Suggest *one* possible cause of a high bacterial colony count in the sushi samples. (1 mark)

(iv) Below is a flowchart showing the major steps for conducting an aerobic bacterial colony count for a sushi sample:

Blend 50 g sample to prepare a 500 mL stock solution

↓

Perform a serial dilution of the stock solution (10^{-1}, 10^{-2}, 10^{-3}, 10^{-4})

↓

Spread each of the diluted solutions over a nutrient agar plate

↓

Incubate at 30°C for 48 hours

↓

Count the number of bacterial colonies formed

↓

Calculate the aerobic bacterial colony count

The photographs below show the bacterial colonies in four agar plates after incubation:

| 10^{-1} plate	10^{-2} plate

10^{-3} plate	10^{-4} plate
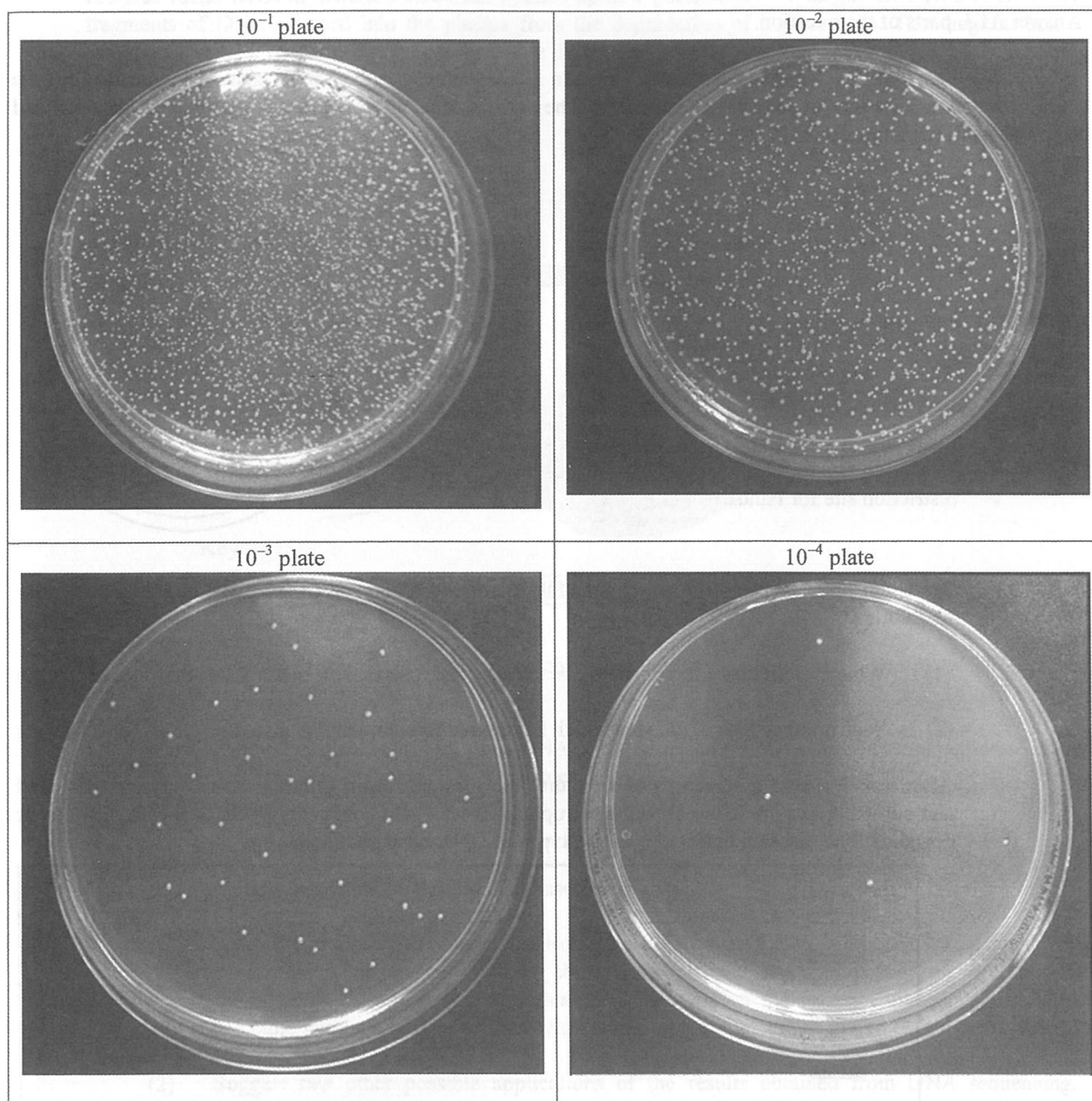
(1) Which agar plate should be selected to count the number of bacterial colonies formed? Explain why other agar plates are not suitable for this counting process. (3 marks)

(2) Count the number of bacterial colonies on the selected agar plate. Calculate the number of bacterial colonies formed per gram of the sushi sample. (2 marks)

(3) In the above process, aseptic techniques should be used to avoid contamination. Describe *one* aseptic technique for spreading the solution over the agar plate. Explain the principle involved. (2 marks)

Answer **ALL** parts of the question.

4(a)   Study the diagrams below. Diagram X shows a DNA segment with a target gene. Diagram Y shows a plasmid with a size of 4 300 base pairs (bp). The restriction sites for restriction enzymes EcoRI, PstI and HindIII are shown in both diagrams.

*Diagram X*

700 bp

target gene

700 bp
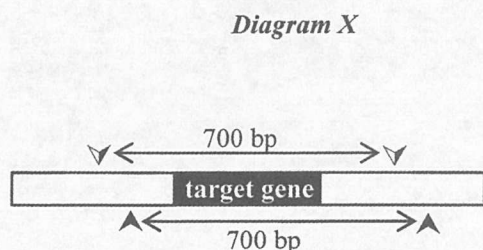
Key: ∨   restriction site for EcoRI
        ▼   restriction site for PstI
        ▽   restriction site for HindIII
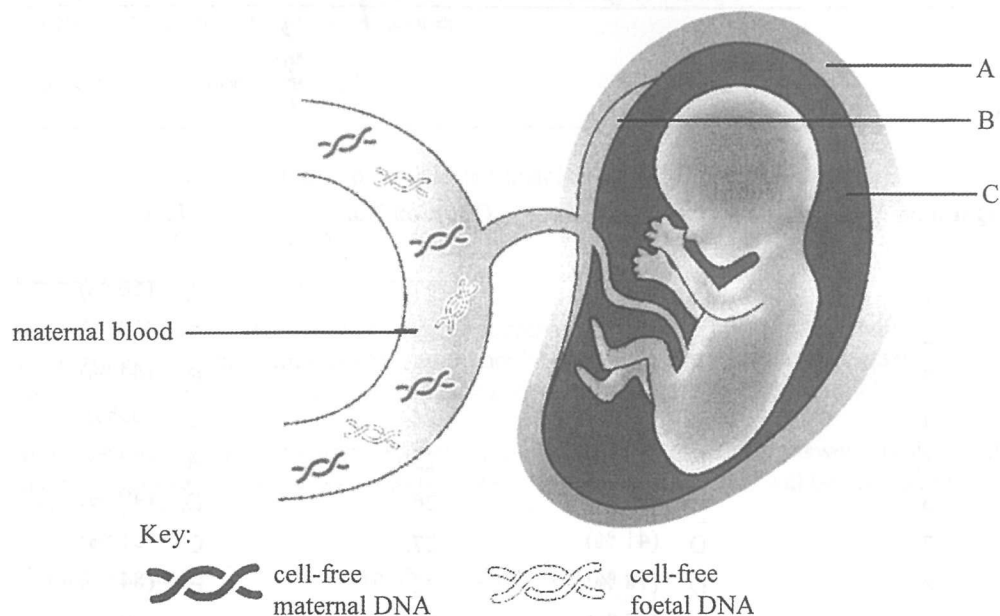
Diagram Y

4 300 bp

antibiotic P resistance gene
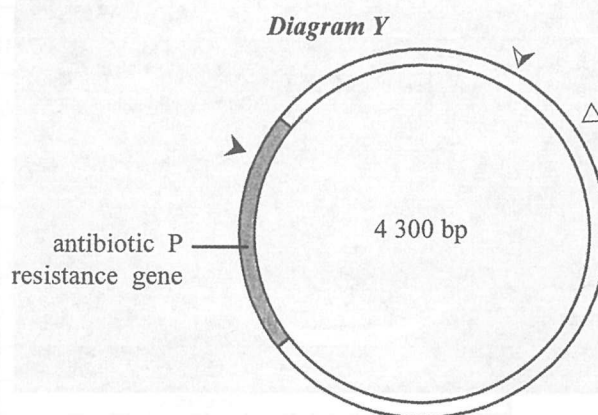
(i)   A student plans to insert the target gene into the plasmid and screen the transformed bacteria with antibiotic P.

(1)   Which restriction enzyme should be used for the insertion? Explain your answer.   (3 marks)

(2)   State another type of enzyme which is required to complete the insertion.   (1 mark)

(ii)   After transformation, screening and culture, the plasmids from different colonies were harvested and cut using enzyme HindIII. Gel electrophoresis was then conducted to check the size of the cut plasmids. The diagram below shows two types of DNA band obtained:
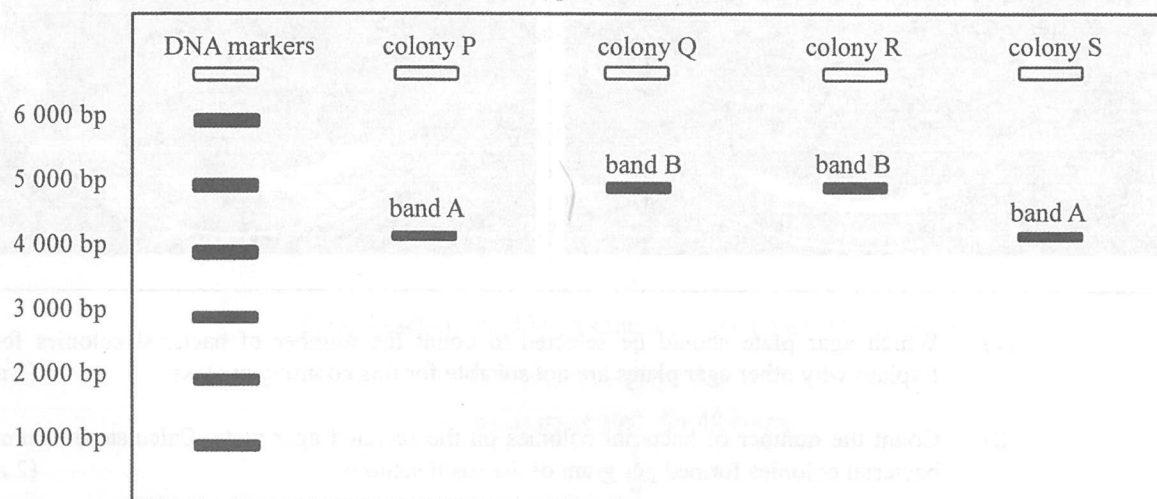
(1)   Which band (A or B) represents the plasmids with the target gene? Explain your answer.
    (3 marks)

(2)   Explain why two types of DNA band were detected in the cut plasmids after gel electrophoresis.   (3 marks)

4(b) Traditional diagnosis of Down Syndrome requires the collection of foetal tissue. The recent discovery of cell-free foetal DNA in maternal blood has opened up new possibilities for diagnosis. Cell-free DNA are fragments of DNA released into the plasma from the degradation of normal cells. The diagram below shows a foetus and its associated structures inside the mother's body:

Key:

 cell-free maternal DNA   cell-free foetal DNA

(i) With reference to the above diagram, which labelled structure does the cell-free foetal DNA come from? Explain your answer. (2 marks)

(ii) In the maternal plasma, cell-free foetal DNA is only a minor proportion of the total cell-free DNA. Suggest a technique for enhancing the detection of very small amounts of cell-free foetal DNA in maternal plasma. Explain your answer. (2 marks)

(iii) Nowadays, the identity of the genes in the cell-free DNA can be found through DNA sequencing and mapping against human genome databases.

(1) Scientists proposed that Down Syndrome could be diagnosed by comparing the frequency of occurrence of the genes found on chromosome 21 and another autosome in the cell-free foetal DNA. Based on your understanding about Down Syndrome, explain the biological principle involved in this method. What would be the expected results? (2 marks)

(2) Suggest *two* other possible applications of the results obtained from DNA sequencing. Explain the principle of each application. (4 marks)

END OF PAPER