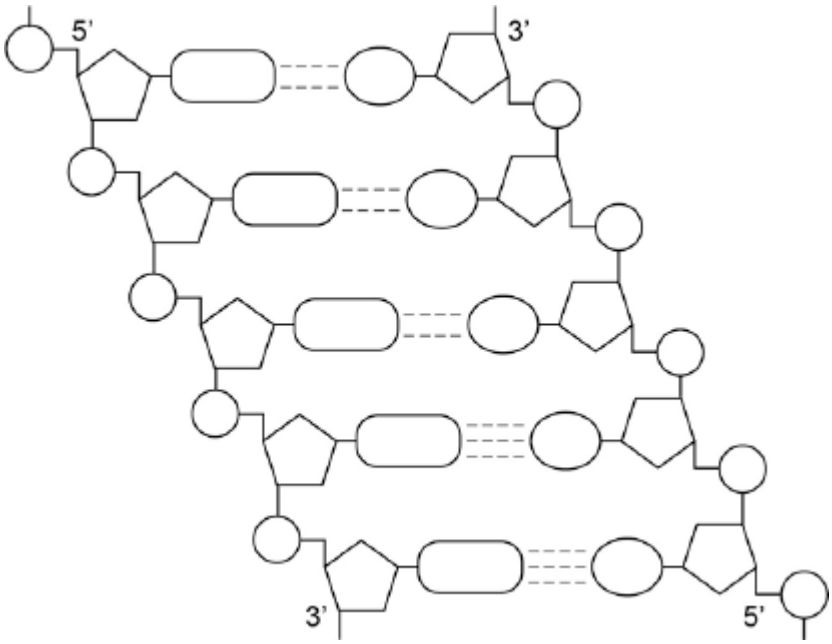
EXAM PAPERS PRACTICE

Nucleic acids 1

Level: AQA AS 7401
Subject: Biology
Exam Board: Suitable for all boards
Topic: Nucleic acids 1
Type: Questionnaire

To be used by all students preparing for AQA AS Biology 7401 foundation or higher tier but also suitable for students of other boards.

1 The following figure represents part of a DNA molecule.



(a) Draw a box around a single nucleotide.

(1)

The table below shows the percentage of bases in each of the strands of a DNA molecule.

DNA strand	**Percentage of each base**			
	A	**C**	**G**	**T**
Strand **1**	16			
Strand **2**		21	34	

(b) Complete the table by adding the missing values.

(2)

(c) During replication, the two DNA strands separate and each acts as a template for the production of a new strand. As new DNA strands are produced, nucleotides can only be added in the 5' to 3' direction.

Use the figure in part **(a)** and your knowledge of enzyme action and DNA replication to explain why new nucleotides can only be added in a 5' to 3' direction.

(Extra space) _____

(4)

(Total 7 marks)

2 Read the following passage.

Malaria is a disease so deadly that it has devastated armies and destroyed great civilisations. It has been estimated that in the course of history malaria has been responsible for the death of one out of every two people who have ever lived. Even today, with all the advantages of modern technology, it is still responsible for some three million deaths a year.

The first half of the twentieth century was a time of hope for malarial control. The drugs chloroquine and proguanil had just been discovered and there seemed a real possibility of a malaria-free world. Unfortunately, this honeymoon ended almost as soon as it had started, with the emergence of drug-resistant parasite populations. Scientists now accept that whatever new drug they come up with, it is likely to have a very limited effective life. As a result, they are increasingly looking at combinations of drugs.

The approach to malaria control which holds the best hope is the production of a vaccine. One of these is being developed by a researcher in South America. His vaccine is based on a small synthetic polypeptide called SPf66 which is dissolved in a saline solution and given as an injection. A series of early trials on human volunteers produced confusing results. In one trial the effectiveness of the vaccine was claimed to be 80% while, in others, the results were statistically insignificant. Not only were the results inconclusive but the methods used were challenged by other scientists. In particular, the controls were considered inappropriate.

Another, possibly more promising, approach has been the development of a DNA-based vaccine. In theory, all that is required is to identify the DNA from the parasite which encodes key antigens. Unfortunately, scientists have hit snags. Although they have succeeded in sequencing the human genome, the genome of the malarial parasite has created major difficulties. This is partly because of the very high proportion of the bases adenine and thymine. In some places these two bases average 80%, and on chromosomes 2 and 3 nearly 100% of the bases present are adenine and thymine. Because of this, it has proved impossible to cut the relevant DNA with the commonly available restriction enzymes into pieces of a suitable size for analysis.

Use information from the passage and your own knowledge to answer the following questions.

(a) Explain how a resistant parasite population is likely to arise and limit the life of any new anti-malarial drug (lines 8 - 9).

(3)

(b) A person has a 1 in 500 probability of being infected by a chloroquine-resistant strain of malarial parasite and a 1 in 500 probability of being infected by a proguanil-resistant strain. Use a calculation from these figures to explain why scientists are “increasingly looking at combinations of drugs” (lines 9 - 10).

_____

_____

_____

_____

(2)

(c) (i) Explain why trials of the SPf66 vaccine needed a control.

_____

_____

(1)

(ii) The controls for the SPf66 vaccine trials were considered inappropriate (line 17).

Suggest how the control groups in these trials should have been treated.

_____

_____

_____

_____

(2)

(d) In some of the DNA of a malarial parasite, the proportion of adenine and thymine bases averages 80% (lines 22 - 23). In this DNA what percentage of the nucleotides would you expect to contain

(i) phosphate; _____

(ii) guanine? _____

(2)

(e) (i) Use your knowledge of enzymes to explain why restriction enzymes only cut DNA at specific restriction sites.

(3)

(ii) Restriction enzymes that can cut the DNA of chromosomes 2 and 3 produce pieces that are too small for analysis. Explain why these restriction enzymes produce small DNA fragments.

(2)

(Total 15 marks)

3 **Essay**

You should write your essay in continuous prose.

Your essay will be marked for its scientific accuracy.

It will also be marked for your selection of relevant material from different parts of the specification and for the quality of your written communication.

The maximum number of marks that can be awarded is

Scientific	16
Breadth of knowledge	3
Relevance	3
Quality of written communication	3

Write an essay on the following topic:

Using DNA in science and technology

(Total 25 marks)

4 (a) DNA helicase is important in DNA replication. Explain why.

_____

_____

_____

_____

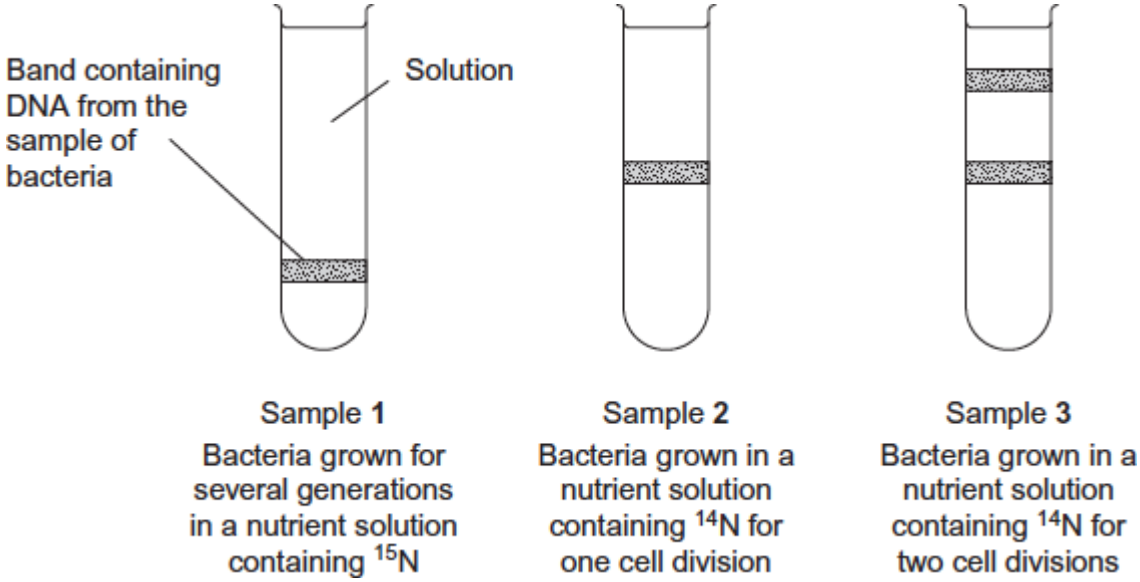
_____

(2)

Scientists investigating DNA replication grew bacteria for several generations in a nutrient solution containing a heavy form of nitrogen (^{15}N). They obtained DNA from a sample of these bacteria.

The scientists then transferred the bacteria to a nutrient solution containing a light form of nitrogen (^{14}N). The bacteria were allowed to grow and divide twice. After each division, DNA was obtained from a sample of bacteria.

The DNA from each sample of bacteria was suspended in a solution in separate tubes. These were spun in a centrifuge at the same speed and for the same time. The diagram shows the scientists' results.



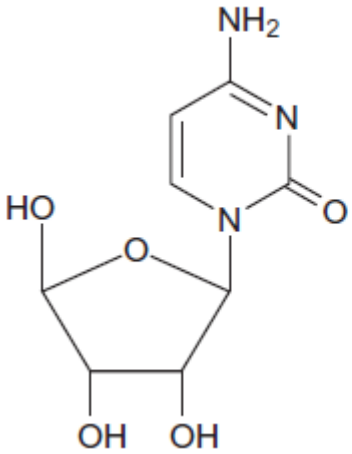
(b) The table shows the types of DNA molecule that could be present in samples **1** to **3**.
Use your knowledge of semi-conservative replication to complete the table with a tick if the DNA molecule is present in the sample.

	Type(s) of DNA molecule present in each sample		
Sample	^{15}N ^{15}N 	^{15}N ^{14}N 	^{14}N ^{14}N 
1			
2			
3			

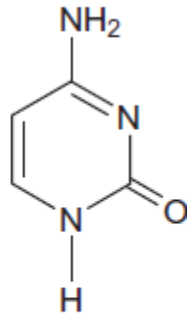
(3)

(c) Cytarabine is a drug used to treat certain cancers. It prevents DNA replication. The diagram shows the structures of cytarabine and the DNA base cytosine.

cytarabine



cytosine



(i) Use information in the diagram to suggest how cytarabine prevents DNA replication.

_____

_____

_____

_____

_____

(2)

(ii) Cytarabine has a greater effect on cancer cells than on healthy cells. Explain why.

_____

_____

_____

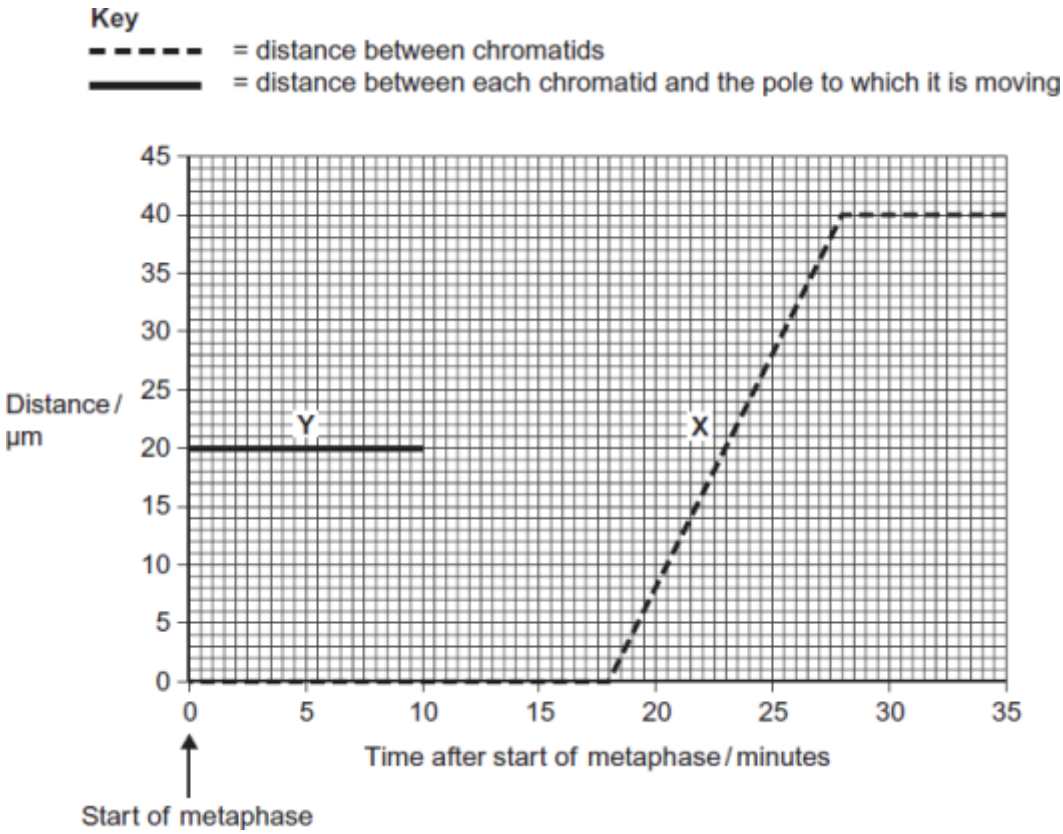
(1)

(Total 8 marks)

5 (a) Describe how DNA is replicated.

(6)

(b) The graph shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.



(i) What was the duration of metaphase in this cell?

☐ minutes

(1)

(ii) Use line **X** to calculate the duration of anaphase in this cell.

☐ minutes

(1)

(iii) Complete line **Y** on the graph.

(2)

(c) A doctor investigated the number of cells in different stages of the cell cycle in two tissue samples, **C** and **D.** One tissue sample was taken from a cancerous tumour. The other was taken from non-cancerous tissue. The table shows his results.

	Percentage of cells in each stage of the cell cycle	
Stage of the cell cycle	Tissue sample **C**	Tissue sample **D**
Interphase	82	45
Prophase	4	16
Metaphase	5	18
Anaphase	5	12
Telophase	4	9

(i) In tissue sample **C**, one cell cycle took 24 hours. Use the data in the table to calculate the time in which these cells were in interphase during one cell cycle. Show your working.

Time cells in interphase _____ hours

(2)

(ii) Explain how the doctor could have recognised which cells were in interphase when looking at the tissue samples.

_____

_____

_____

(1)

(iii) Which tissue sample, **C** or **D**, was taken from a cancerous tumour?
Use information in the table to explain your answer.

_____

_____

_____

_____

_____

(2)

(Total 15 marks)

6 (a) Nucleic acids, such as DNA, are polymers, made up of many repeating monomer units.
Name the monomer from which nucleic acids are made.

_____

(1)

(b) The table shows the percentage of different bases in the DNA of some organisms.

Organism	**Percentage of each base**			
	Adenine	**Guanine**	**Cytosine**	**Thymine**
Human	31.2	18.8	18.8	31.2
Cow	27.9	22.1	22.1	27.9
Salmon	29.4	20.6	20.6	29.4
Rat	28.6			
Virus	24.7	24.1	18.5	32.7

(i) Calculate the missing figures for rat DNA and write them into the table.

(2)

(ii) The virus has single-stranded DNA as its genetic material. Explain the evidence from the table which suggests that the DNA is single-stranded.

_____

_____

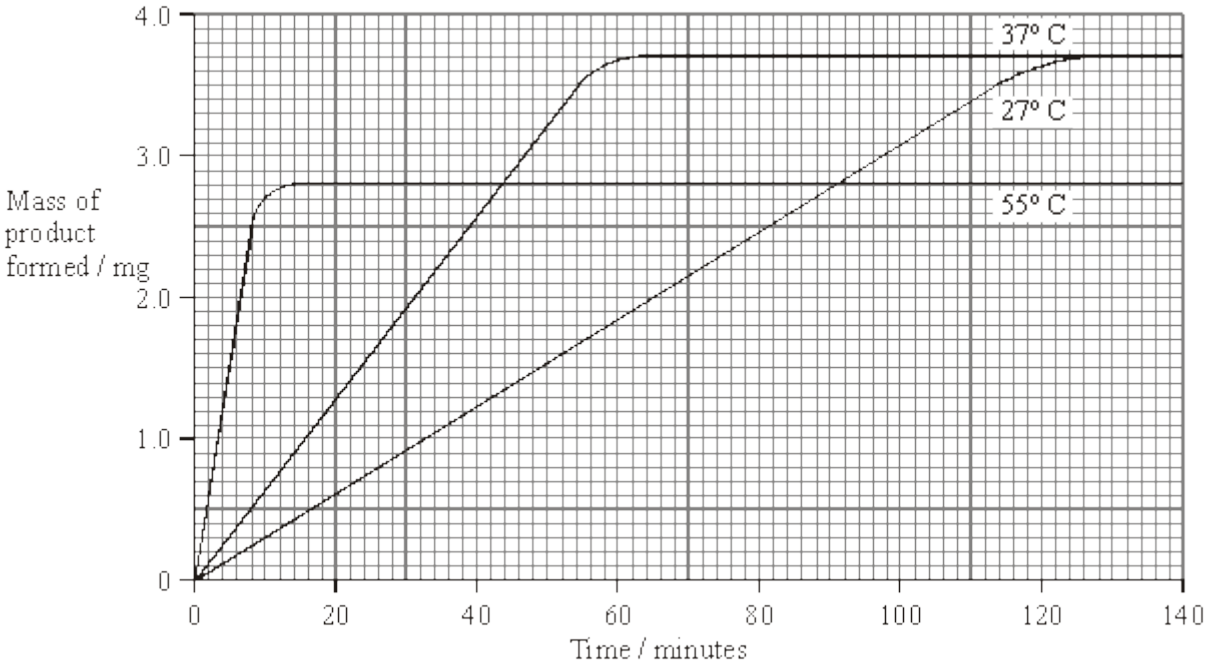
_____

_____

(2)

(Total 5 marks)

7 A student carried out an investigation into the mass of product formed in an enzyme-controlled reaction at three different temperatures. Only the temperature was different for each experiment. The results are shown in the graph.



(a) Use your knowledge of enzymes to explain

(i) why the initial rate of reaction was highest at 55 °C;

_____

_____

_____

_____

(2)

(ii) the shape of the curve for 55 °C after 20 minutes.

(3)

(b) Explain why the curves for 27 °C and 37 °C level out at the same value.

(2)

(Total 7 marks)

8 (a) Explain how the structure of DNA is related to its functions.

(Extra space)

(6)

Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division.
They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol N.
- If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different combinations of N and M alleles of the genes. A risk value of 1.00 indicates no increased risk.
The following table shows the scientists' results.

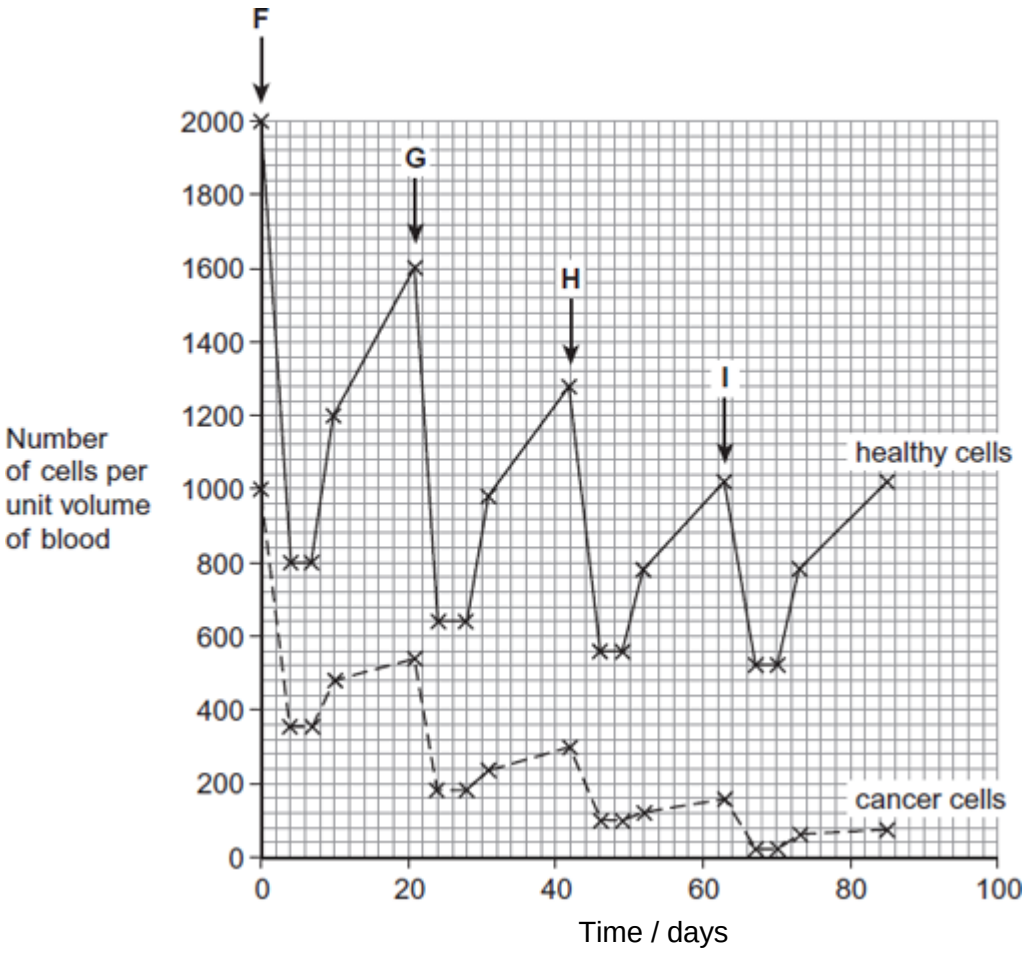
Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

(b) What do these data suggest about the relative importance of the mutant alleles of genes **C**, **D** and **E** on **increasing** the risk of developing lung cancer? Explain your answer.

(3)

Chemotherapy is the use of a drug to treat cancer. The drug kills dividing cells.
The figure below shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.



(c) Calculate the rate at which healthy cells were killed between days 42 and 46.

_____ cells killed per unit volume of blood per day

(1)

(d) Describe similarities and differences in the response of healthy cells and cancer cells to the drug between times **F** and **G**.

(Extra space)

(3)

(e) More cancer cells could be destroyed if the drug was given more frequently.

Suggest why the drug was **not** given more frequently.

(2)

(Total 15 marks)

9 (a) Describe and explain how the structure of DNA results in accurate replication.

(4)

(b) Describe the behaviour of chromosomes during mitosis and explain how this results in the production of two genetically identical cells.

(7)

(c) A cancerous tumour is formed by uncontrolled mitotic division. This results in a mass of cells with an inadequate blood supply. Drugs are being developed which only kill cells in a low oxygen environment. Suggest how these drugs could be useful in the treatment of cancer.

(2)

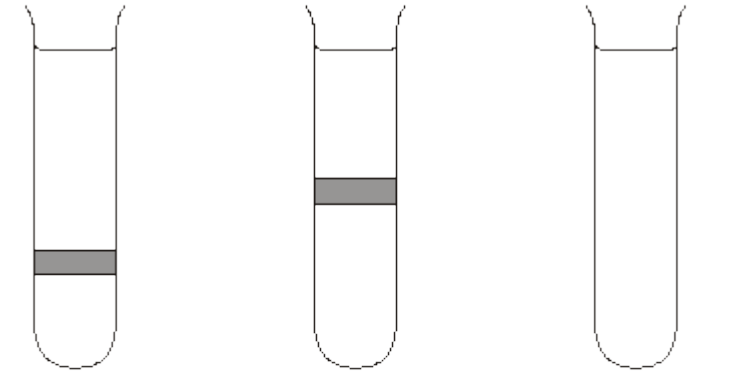
(Total 13 marks)

10 (a) There are two forms of nitrogen. These different forms are called isotopes. ^{15}N is a heavier isotope than the normal isotope ^{14}N.

In an investigation, a culture of bacteria was obtained in which all the nitrogen in the DNA was of the ^{15}N form. The bacteria (generation 0) were transferred to a medium containing only the normal isotope, ^{14}N, and allowed to divide once. A sample of these bacteria (generation 1) was then removed. The DNA in the bacteria of generation 1 was extracted and spun in a high-speed centrifuge.

The bacteria in the ^{14}N medium were allowed to divide one more time. The DNA was also extracted from these bacteria (generation 2) and spun in a high speed centrifuge.

The diagram shows the results of this investigation.



(i) Which part of the DNA molecule contains nitrogen?

_____

(1)

(ii) Explain why the DNA from generation 1 is found in the position shown.

_____

_____

_____

_____

(2)

(iii) Complete the diagram to show the results for generation 2.

(2)

(b) The table shows the percentage of different bases in the DNA of different organisms.

Organism	Adenine%	Guanine%	Thymine%	Cytosine%
Human		19		
Bacterium	24	26	24	26
Virus	25	24	33	18

(i) Complete the table to show the percentages of different bases in human DNA.

(2)

(ii) The structure of virus DNA is different from the DNA of the other two organisms. Giving evidence from the table, suggest what this difference might be.

_____

_____

_____

_____

(2)

(Total 9 marks)

11 (a) Starch and protein are biologically important polymers.

(i) Explain what is meant by a polymer.

_____

_____

(1)

(ii) Give **one** example of a biologically important polymer other than starch or protein.

_____

(1)

(b) In an investigation, the enzyme amylase was mixed in a test tube with a buffer solution and a suspension of starch. The amylase broke down the starch to maltose. When all the starch had been broken down, a sample was removed from the test tube and tested with biuret reagent.

(i) Explain why a buffer solution was added to the amylase-starch mixture.

_____

_____

_____

(2)

(ii) What colour would you expect the sample to go when tested with biuret reagent?

_____

(1)

(iii) Give an explanation for your answer to part (ii)

_____

_____

_____

(2)

(Total 7 marks)

12 (a) The genetic code is **degenerate** and **non-overlapping**.

Explain the meaning of:

Degenerate_____

_____

Non-overlapping_____

_____

(2)

The table shows a short section of a messenger RNA (mRNA) molecule and the section of a polypeptide for which it codes.

mRNA	G G G	G C U	U C A	C C G	G C A	A C G
Polypeptide	glycine	alanine	serine	proline	alanine	threonine

(b) Name the bases represented in the table by:

A _____

C _____

G _____

U _____

(2)

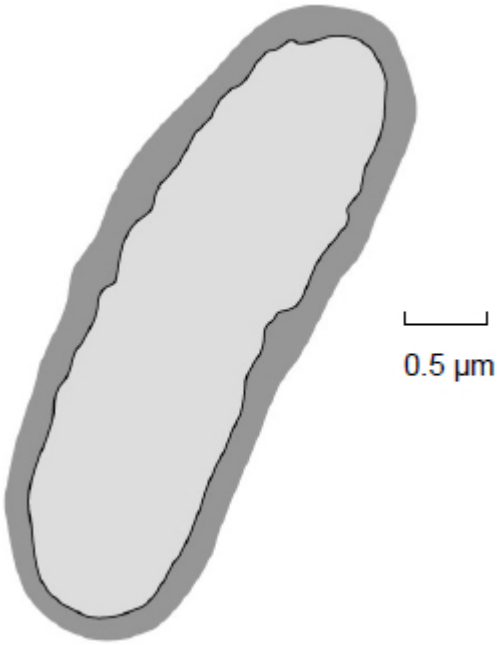
(c) Use information in the table to give the sequence of bases in **DNA** that codes for serine.

_____

(1)

(Total 5 marks)

13 A bacterium is shown in the diagram.



(a) Calculate the magnification of the image.

Magnification = _____

(1)

(b) Complete the table to show the features of a bacterium and a virus.

Put a tick (✓) in the box if the feature is shown.

Surface	Bacterium	Virus
Cell-surface membrane		
Nucleus		
Cytoplasm		
Capsid		

(2)

(c) DNA and RNA can be found in bacteria.

Give **two** ways in which the nucleotides in DNA are different from the nucleotides in RNA.

1. _____

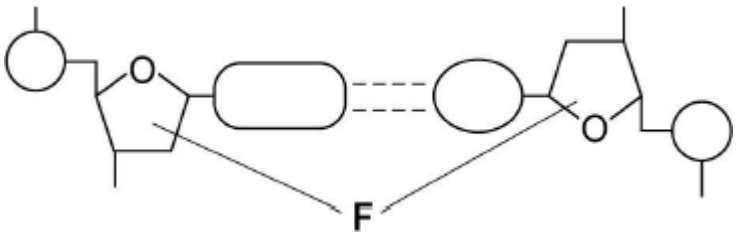
2. _____

(2)

(Total 5 marks)

14 **Figure 1** shows one base pair of a DNA molecule.

Figure 1



(a) Name part **F** of each nucleotide.

_____

(1)

(b) Scientists determined that a sample of DNA contained 18% adenine.

What were the percentages of thymine and guanine in this sample of DNA?

Percentage of thymine ☐

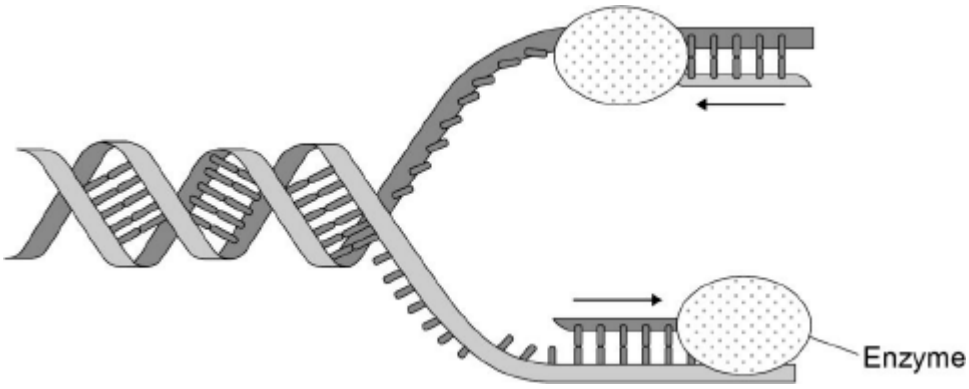
Percentage of guanine ☐

(2)

During replication, the two strands of a DNA molecule separate and each acts as a template for the production of a new strand.

Figure 2 represents DNA replication.

Figure 2



(c) Name the enzyme shown in **Figure 2**.

_____

(1)

The arrows in **Figure 2** show the directions in which each new DNA strand is being produced.

(d) Use **Figure 1, Figure 2** and your knowledge of enzyme action to explain why the arrows point in opposite directions.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 8 marks)

15 Read the following passage.

Herpes simplex virus (HSV) infects nerve cells in the face, including some near the lips. Like many other viruses, HSV can remain inactive inside the body for years. When HSV becomes active, it causes cold sores around the mouth.

Human cells infected with a virus may undergo programmed cell death. While HSV is inactive inside the body, only one of its genes is transcribed. This gene is the latency-associated transcript (*LAT*) gene that prevents programmed cell death of an infected nerve cell.

Scientists have found that transcription of the *LAT* gene produces a microRNA. This microRNA binds to some of the nerve cell's own mRNA molecules. These mRNA molecules are involved in programmed cell death of nerve cells. The scientists concluded that production of this microRNA allows HSV to remain in the body for years.

Use information from the passage and your own knowledge to answer the following questions.

(a) HSV infects nerve cells in the face (line 1). Explain why it infects **only** nerve cells.

(Extra space) _____

(3)

(b) HSV can remain inactive inside the body for years (lines 2–3). Explain why this virus can be described as **inactive**.

(2)

(c) Suggest **one** advantage of programmed cell death (line 4).

_____

_____

(1)

(d) The scientists concluded that production of this microRNA allows HSV to remain in the body for years (lines 10–12).

Explain how this microRNA allows HSV to remain in the body for years.

_____

_____

_____

_____

_____

_____

_____

_____

(Extra space) _____

_____

_____

_____

(4)

(Total 10 marks)