BIOLOGICAL MOLECULES

Nucleic Acids – Genes Part 2 EXAM Q&A

Q1.

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

(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.

_____

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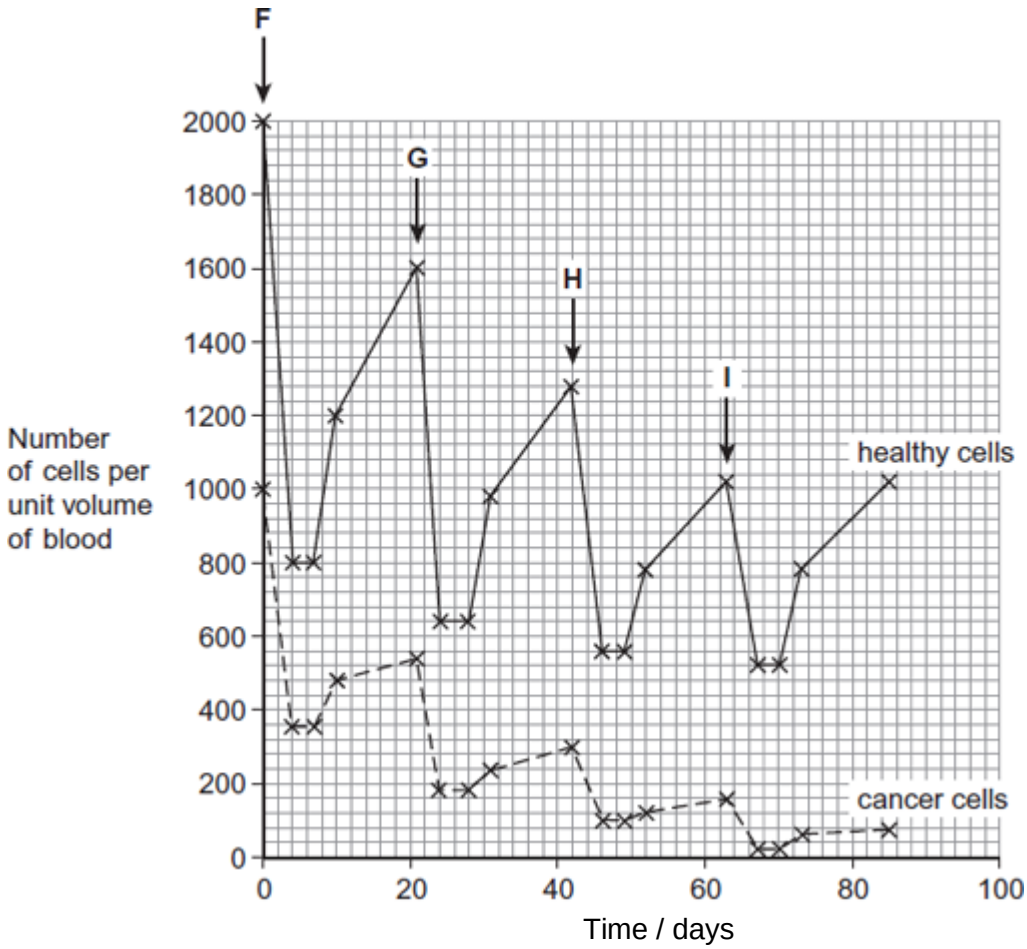
(3)

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**.

_____

_____

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(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)

Q2.

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

_____

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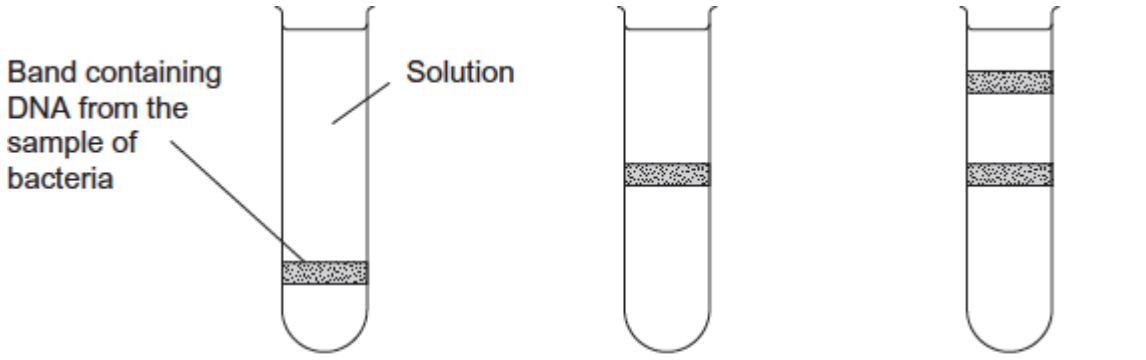
(2)

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.



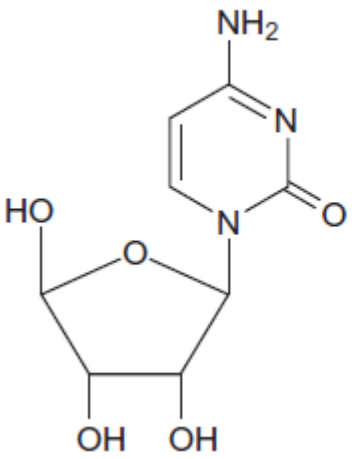
(b) The table shows the types of DNA molecule that could be present in samples **1** to **3**. Use your knowledge of semi-conservative replication to complete the table with a tick if the DNA molecule is present in the sample.

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

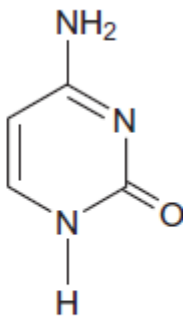
(3)

(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)

Q3.

(a) Describe how DNA is replicated.

_____

_____

_____

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_____

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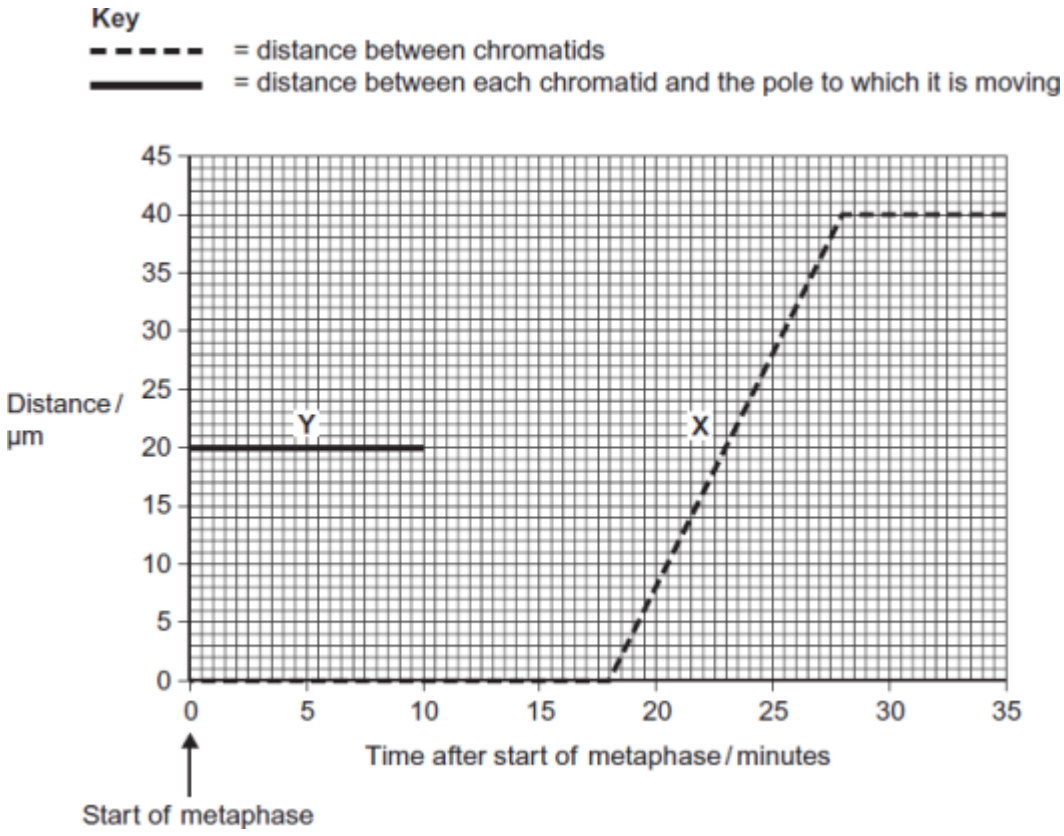
_____

_____

(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.

_____

_____

_____

_____

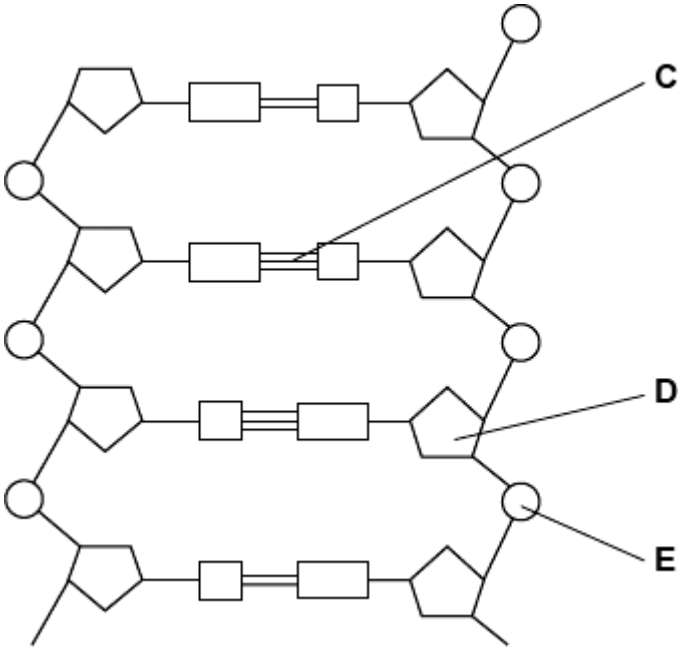
_____

(2)

(Total 15 marks)

Q4.

The diagram shows part of a DNA molecule.



(a) (i) DNA is a polymer. What is the evidence from the diagram that DNA is a polymer?

_____

_____

_____

(1)

(ii) Name the parts of the diagram labelled **C**, **D** and **E**.

Part **C** _____

Part **D** _____

Part **E** _____

(3)

(iii) In a piece of DNA, 34% of the bases were thymine.

Complete the table to show the names and percentages of the other bases.

Name of base	Percentage
Thymine	34
	34

(2)

(b) A polypeptide has 51 amino acids in its primary structure.

(i) What is the minimum number of DNA bases required to code for the amino acids in this polypeptide?

(1)

(ii) The gene for this polypeptide contains more than this number of bases.

Explain why

_____

_____

_____

(1)

(Total 8 marks)

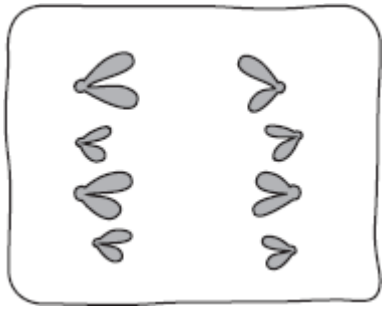
Q5.

Write an essay on the importance of shapes fitting together in cells and organisms.

(Total 25 marks)

Q6.

(a) The diagram shows a stage of mitosis in an animal cell.



(i) Name this stage.

_____

(1)

(ii) Describe what happens during this stage that results in the production of two genetically identical cells.

_____

_____

_____

_____

_____

(2)

(b) A sample of epithelial tissue from the small intestine of an animal was analysed. Some of the cells had 8.4 units of DNA, others had only 4.2 units.

(i) Use your knowledge of the cell cycle to explain why some cells had 8.4 units of DNA and others had only 4.2 units.

_____

_____

_____

_____

_____

(2)

(ii) How many units of DNA would you expect to be present in a gamete formed in this animal as a result of meiosis?

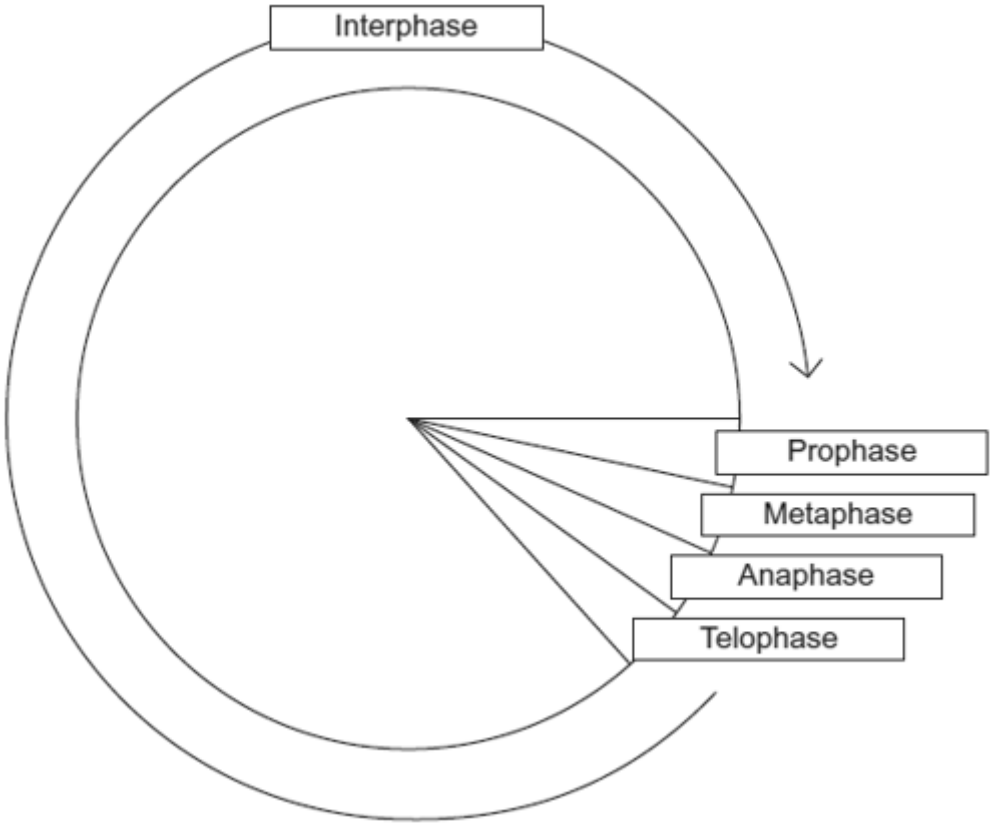
☐

(1)

(Total 6 marks)

Q7.

The diagram shows a cell cycle.



(a) In prophase of mitosis, the chromosomes become visible. Describe what happens

in

(i) metaphase

_____

_____

_____

_____

_____

(2)

(ii) anaphase.

_____

_____

_____

_____

_____

(2)

(b) (i) Cells lining the human intestine complete the cell cycle in a short time.
Explain the advantage of these cells completing the cell cycle in a short time.

_____

_____

_____

(1)

(ii) The time required for a cell to complete the cell cycle was 4 hours 18 minutes.

Calculate the time required in minutes for this cell to multiply to produce eight cells.
Show your working.

Answer _____

(2)

(c) Mikanolide is a drug that inhibits the enzyme DNA polymerase. Explain why this

drug may be effective against some types of cancer.

_____

_____

_____

_____

_____

(2)

(Total 9 marks)

Q8.

Write an essay on using DNA in science and technology.

(Total 25 marks)

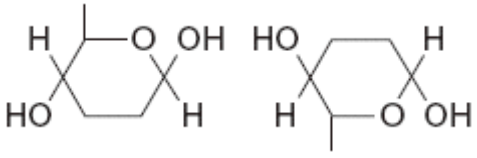
Q9.

(a) The table shows some substances found in cells. Complete the table to show the properties of these substances. Put a tick in the box if the statement is correct.

Statement	**Substance**			
	Starch	Glycogen	Deoxyribose	DNA helicase
Substance contains only the elements carbon, hydrogen and oxygen				
Substance is made from amino acid monomers				
Substance is found in both animal cells and plant cells				

(4)

(b) The diagram shows two molecules of β-glucose.



On the diagram, draw a box around the atoms that are removed when the two β-glucose molecules are joined by condensation.

(2)

(c) (i) Hydrogen bonds are important in cellulose molecules. Explain why.

_____

_____

_____

_____

(2)

(ii) A starch molecule has a spiral shape. Explain why this shape is important to its function in cells.

_____

_____

_____

(1)

(Total 9 marks)

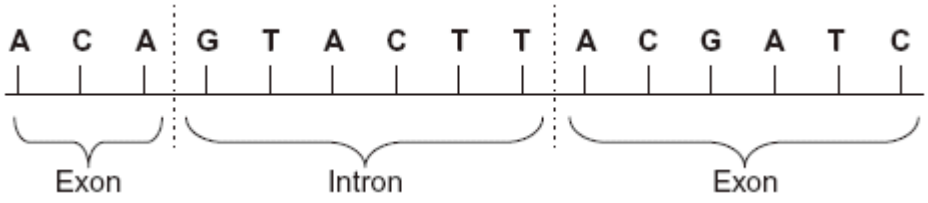
Q10.

(a) Complete the table to show the differences between DNA, mRNA and tRNA.

Type of nucleic acid	Hydrogen bonds present (✓) or not present (✗)	Number of polynucleotide strands in molecule
DNA		
mRNA		
tRNA		

(2)

(b) The diagram shows the bases on one strand of a piece of DNA.



(i) In the space below, give the sequence of bases on the pre-mRNA transcribed from this strand.

(2)

(ii) In the space below, give the sequence of bases on the mRNA produced by splicing this piece of pre-mRNA.

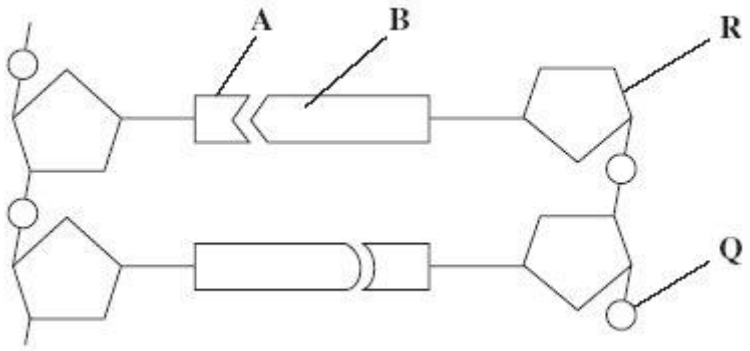
(1)

(Total 5 marks)

Q11.

Figure 1 shows a short section of a DNA molecule.

Figure 1



(a) Name parts **R** and **Q**.

(i) **R** _____

(ii) **Q** _____

(2)

(b) Name the bonds that join **A** and **B**.

_____

(1)

(c) Ribonuclease is an enzyme. It is 127 amino acids long.

What is the minimum number of DNA bases needed to code for ribonuclease?

(1)

(d) **Figure 2** shows the sequence of DNA bases coding for seven amino acids in the enzyme ribonuclease.

Figure 2

G T T T A C T A C T C T T C T T C T T T A

The number of each type of amino acid coded for by this sequence of DNA bases is shown in the table.

Amino acid	Number present
Arg	3
Met	2
Gln	1
Asn	1

Use the table and **Figure 2** to work out the sequence of amino acids in this part of the enzyme. Write your answer in the boxes below.

Gln						

(1)

(e) Explain how a change in a sequence of DNA bases could result in a non-functional enzyme.

_____

_____

_____

_____

_____

_____

(3)

(Total 8 marks)

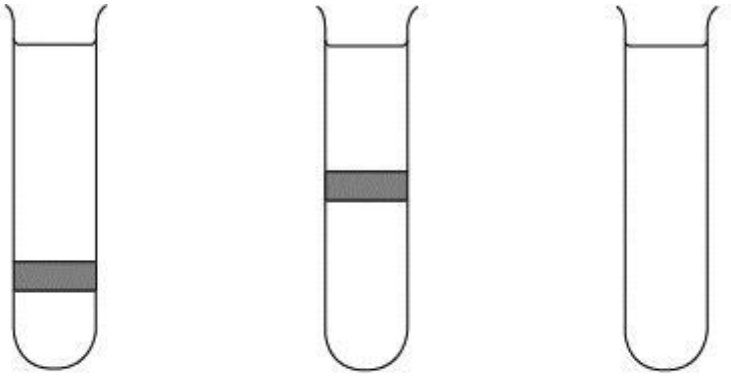
Q12.

(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.



Generation 0 DNA from bacteria with ^{15}N only

Generation 1 DNA from bacteria which have divided once in a ^{14}N medium

Generation 2 DNA from bacteria which have divided twice in a ^{14}N medium

(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)

Q13.

(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)

Q14.

(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)

_____

_____

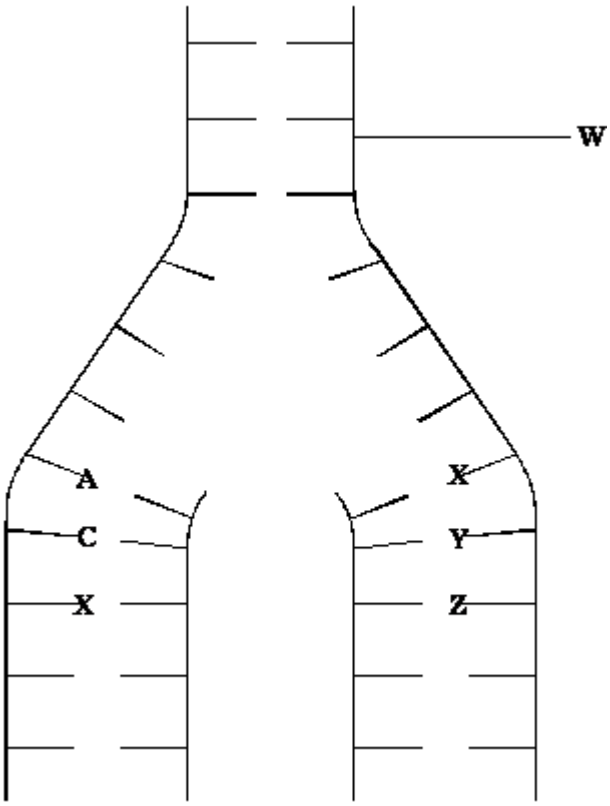
_____

(2)

(Total 7 marks)

Q15.

The diagram shows the process of DNA replication. The horizontal lines represent the positions of bases.



(i) What is represented by the part of the DNA molecule labelled **W**?

_____

(1)

(ii) In the diagram, **A** represents adenine and **C** represents cytosine.

Name the base found at

position **X**; _____

position **Y**; _____

position **Z**. _____

(3)

(Total 4 marks)

Q16.

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)

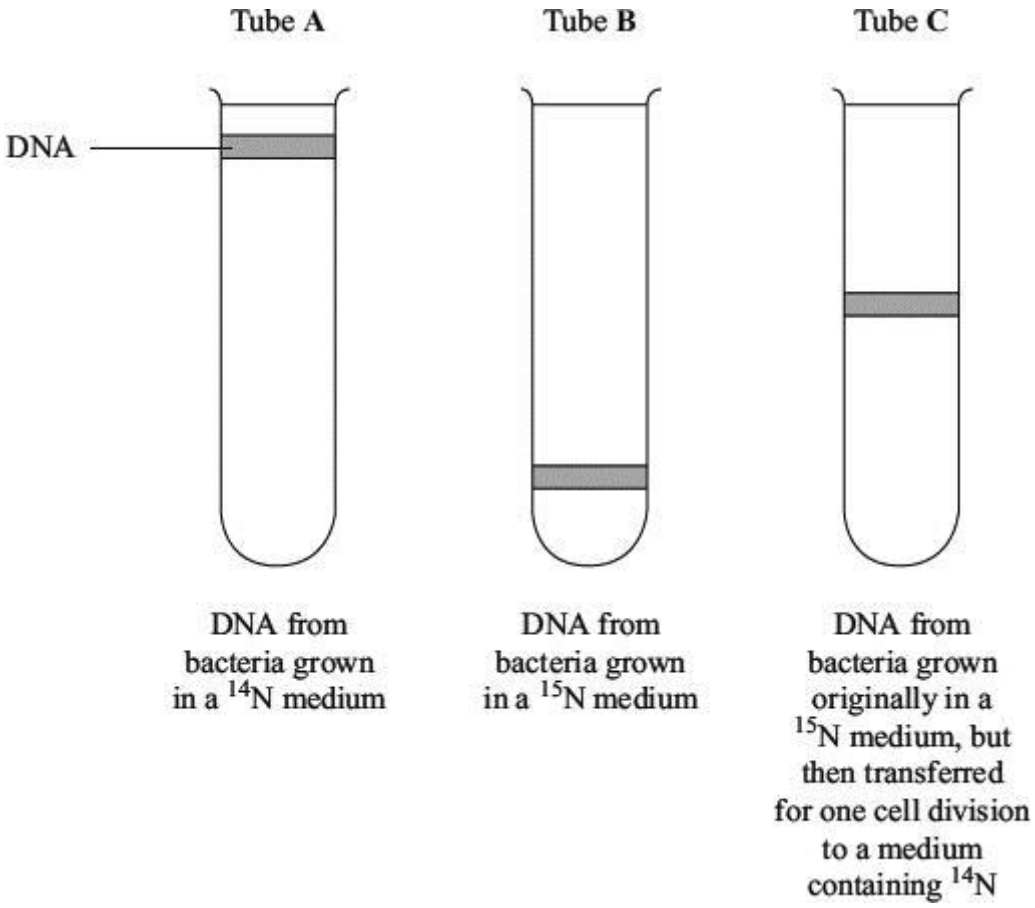
Q17.

(a) Explain why the replication of DNA is described as semi-conservative.

_____

(2)

(b) Bacteria require a source of nitrogen to make the bases needed for DNA replication. In an investigation of DNA replication some bacteria were grown for many cell divisions in a medium containing ^{14}N, a light form of nitrogen. Others were grown in a medium containing ^{15}N, a heavy form of nitrogen. Some of the bacteria grown in a ^{15}N medium were then transferred to a ^{14}N medium and left to divide once. DNA was isolated from the bacteria and centrifuged.
The DNA samples formed bands at different levels, as shown in the diagram.



(i) What do tubes **A** and **B** show about the density of the DNA formed using the two different forms of nitrogen?

(1)

(ii) Explain the position of the band in tube **C**.

(2)

(c) In a further investigation, the DNA of the bacterium was isolated and separated into single strands. The percentage of each nitrogenous base in each strand was found. The table shows some of the results.

	Percentage of base present			
DNA sample	Adenine	Cytosine	Guanine	Thymine
Strand 1	26		28	14
Strand 2	14			

Use your knowledge of base pairing to complete the table.

(2)

(Total 7 marks)

Q18.

(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)

Q19.

(a) The mRNA codon for the amino acid tyrosine is UAU.

(i) Give the DNA triplet for tyrosine.

(1)

(ii) Give the tRNA anticodon for tyrosine.

(1)

(b) Give **two** ways in which the structure of a molecule of tRNA differs from the structure of a molecule of mRNA.

1.

2.

(2)

(Total 4 marks)

Q20.

New alleles arise as a result of mutations in existing genes. These mutations may occur during DNA replication.

(a) Explain what is meant by an allele.

(1)

(b) Explain how DNA replicates.

(4)

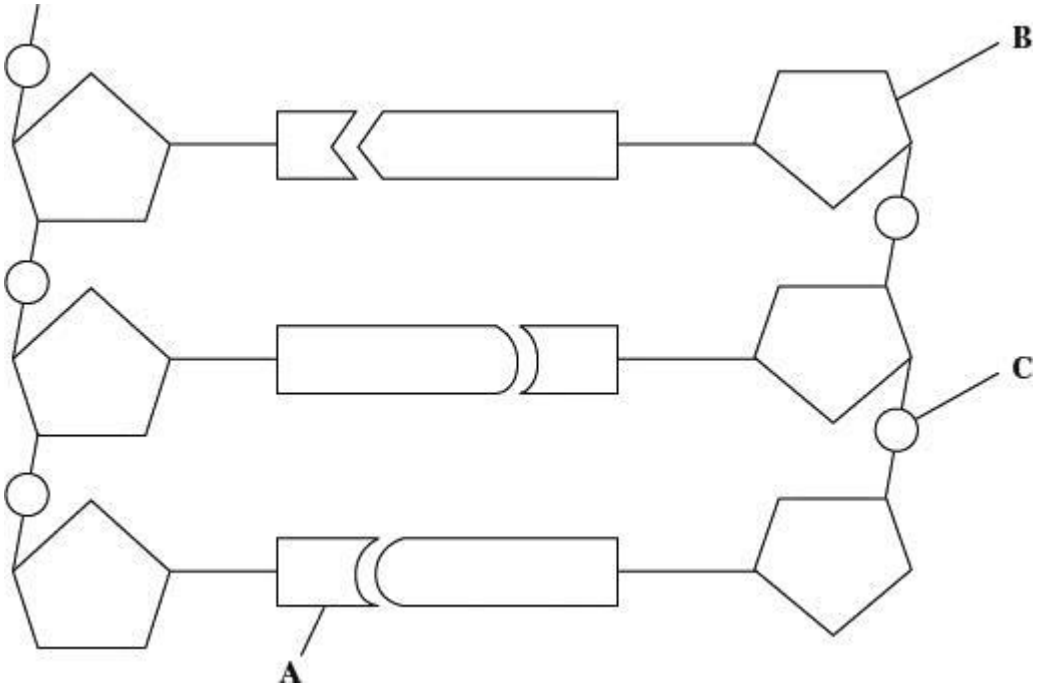
(c) Explain why a mutation involving the deletion of a base may have a greater effect than one involving substitution of one base for another.

(3)

(Total 8 marks)

Q21.

The diagram shows a short section of a DNA molecule.



(a) On the diagram draw a box round **one** nucleotide.

(1)

(b) Use the letters in the diagram to indicate a part of the molecule which

(i) is **not** a base and is different in an RNA molecule;

_____

(ii) contains nitrogen.

_____

(2)

(c) (i) The sequence of bases on one strand of DNA is important for protein synthesis. What is its role?

_____

_____

(1)

(ii) How are the two strands of the DNA molecule held together?

_____

(1)

(iii) Give **one** advantage of DNA molecules having two strands.

_____

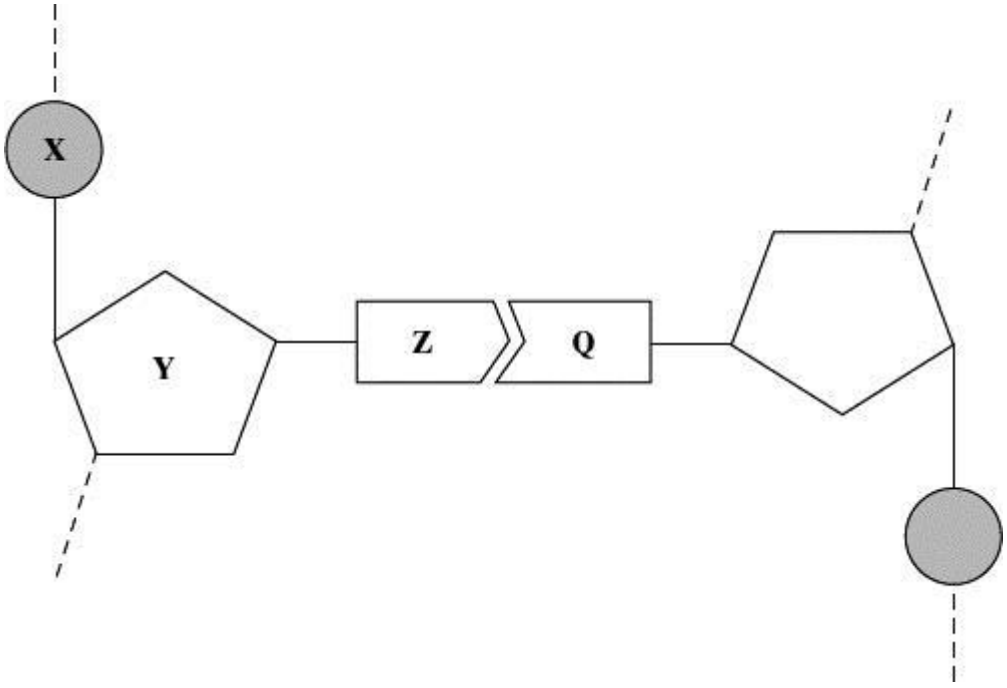
_____

(1)

(Total 6 marks)

Q22.

The diagram shows one nucleotide pair of a DNA molecule.



(a) Name the parts of the nucleotide labelled **X**, **Y** and **Z**.

X _____

Y _____

Z _____

(3)

(b) What type of bond holds **Z** and **Q** together?

_____

(1)

(c) A sample of DNA was analysed. 28% of the nucleotides contained thymine. Calculate the percentage of nucleotides which contained cytosine. Show your working.

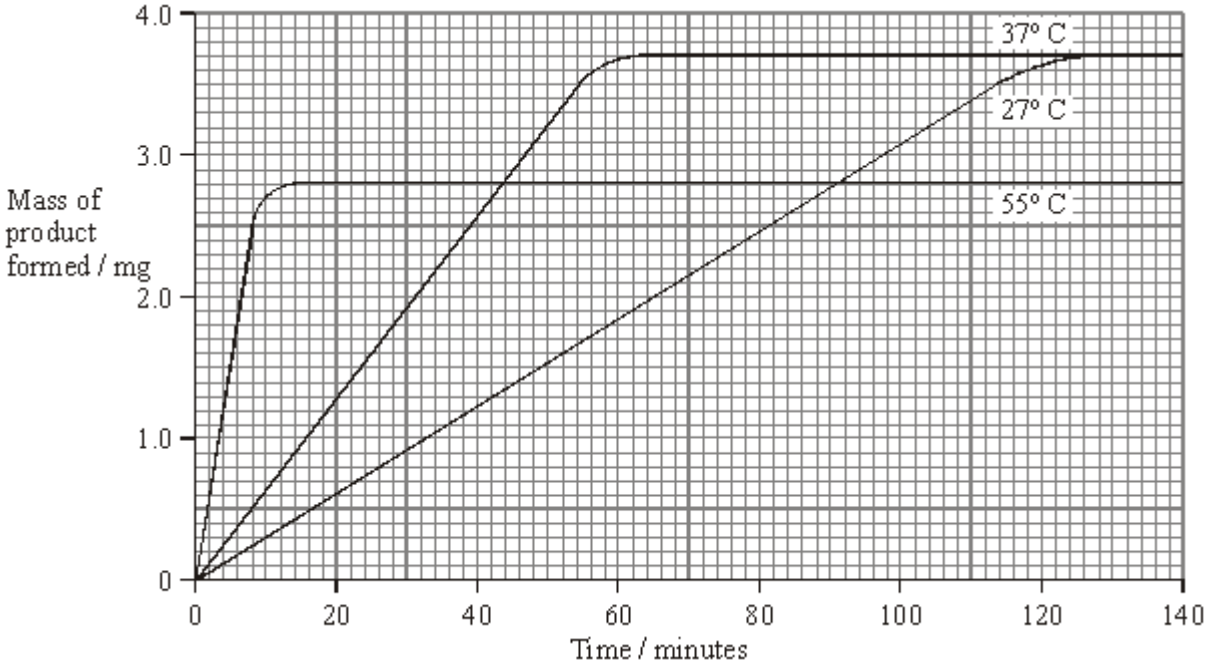
Answer _____ %

(2)

(Total 6 marks)

Q23.

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)

Q24.

(a) Complete the table to give **two** differences between DNA and RNA.

Difference	DNA	RNA
1		
2		

(2)

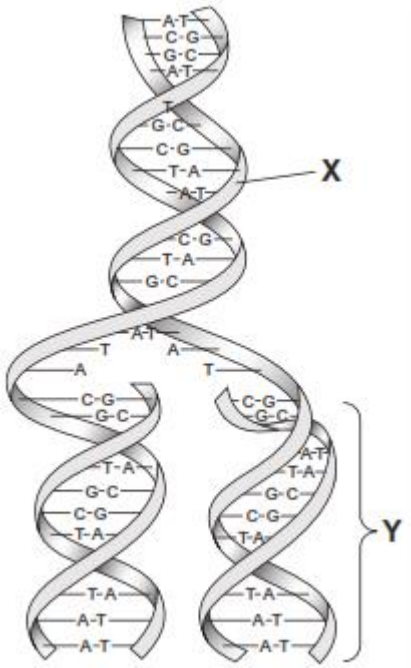
(b) Describe the part played by RNA in protein synthesis.

(Extra space)

(3)
(Total 5 marks)

Q25.

The diagram shows a molecule of DNA. It is replicating.



(a) Name **two** substances in the region labelled **X**.

1. _____

2. _____

(1)

(b) Describe how, after the parent DNA strands separated, the second strand of DNA in region **Y** was formed.

_____

_____

_____

_____

_____

_____

(*Extra space*) _____

_____

_____

(3)

(Total 4 marks)

Q26.

(a) Complete the table to show **two** differences between the structure of DNA and RNA.

DNA	RNA

(2)

(b) Explain how a gene codes for a protein.

_____

_____

_____

_____

(2)

(c) What are homologous chromosomes?

_____

_____

_____

_____

(2)

(Total 6 marks)

Q27.

The bases in DNA nucleotides contain nitrogen.

Researchers grew bacteria on a medium containing ^{15}N ('heavy' nitrogen) for several generations. They then transferred the bacteria to a medium containing ^{14}N ('ordinary' nitrogen). They analysed DNA from the bacteria at three stages:

1. whilst the bacteria were growing on the ^{15}N medium

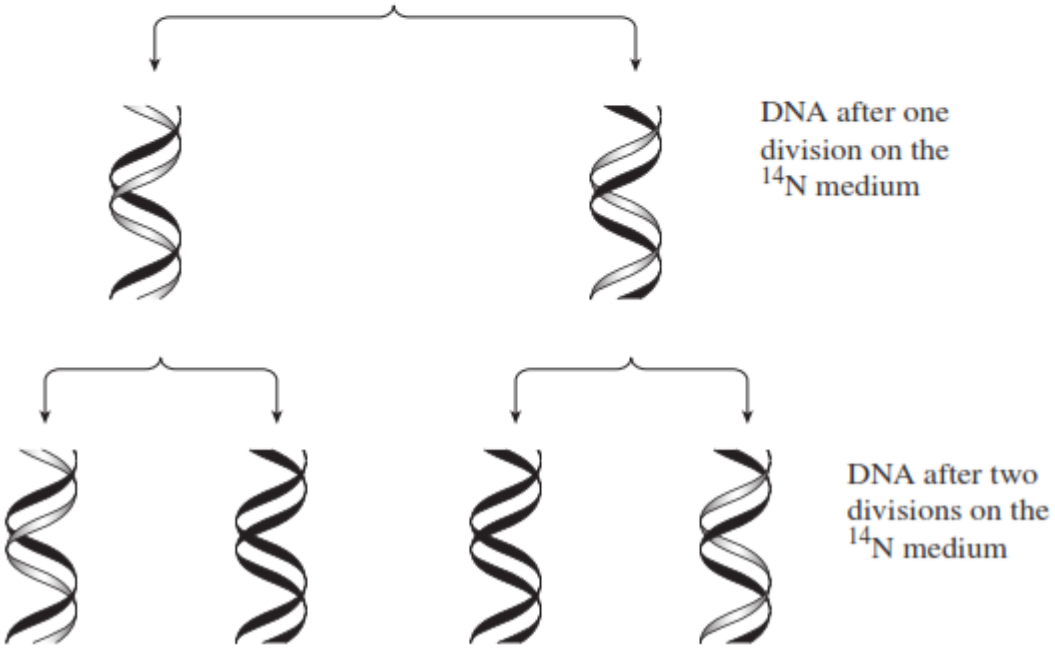
2. after one division of the bacteria on the ^{14}N medium

3. after two divisions of the bacteria on the ^{14}N medium

The diagram shows their results.

Bacteria are grown on ^{15}N medium

Bacteria are then transferred to ^{14}N medium



(a) Describe how the proportion of DNA that contained ^{15}N changed at each division when bacteria were grown on the ^{14}N medium.

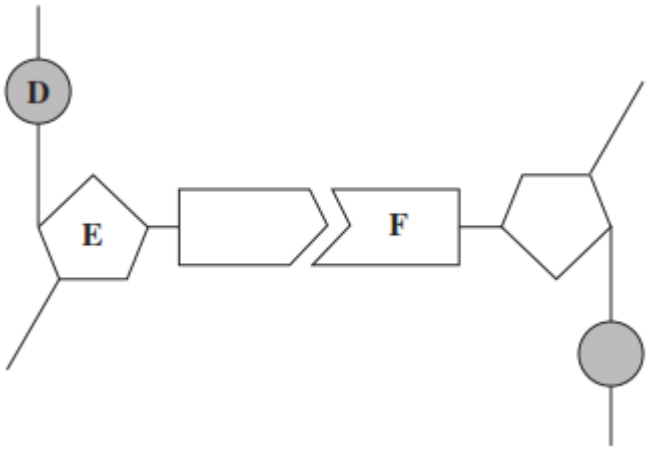
(2)

(b) The change in the proportion of DNA containing ^{15}N is due to the way in which DNA replicates. Explain how.

(2)
(Total 4 marks)

Q28.

(a) The diagram shows one pair of nucleotides of a DNA molecule.



Name

D _____

E _____

F _____

(3)

(b) Complete the table to give **two** differences between the structure of DNA and the structure of RNA.

	DNA	RNA
1		
2		

(2)
(Total 5 marks)

Q1.

(a) 1. Sugar-phosphate (backbone) / double stranded / helix **so** provides strength / stability / protects bases / protects hydrogen bonds;

Must be a direct link / obvious to get the mark

Neutral: reference to histones

2. Long / large molecule **so** can store lots of information;

3. Helix / coiled **so** compact;

Accept: can store in a small amount of space for 'compact'

4. Base sequence allows information to be stored / base sequence codes for amino acids / protein;

Accept: base sequence allows transcription

5. Double stranded **so** replication can occur semi-conservatively / strands can act as templates / complementary base pairing / A-T and G-C so accurate replication / identical copies can be made;

6. (Weak) hydrogen bonds **for** replication / unzipping / strand separation / many hydrogen bonds **so** stable / strong;

Accept: 'H-bonds' for 'hydrogen bonds'

6

(b) 1. (Mutation) in **E** produces highest risk / 1.78;

2. (Mutation) in **D** produces next highest risk / 1.45;

3. (Mutation) in **C** produces least risk / 1.30;

Must be stated directly and not implied

E > ***D*** > ***C*** *= 3 marks*

Accept: values of 0.78, 0.45 and 0.30 for MP1, MP2 and MP3 respectively

If no mark is awarded, a principle mark can be given for the idea that all mutant alleles increase the risk

3

(c) **180**;

1

(d) **(Similarities):**

1. Same / similar pattern / both decrease, stay the same then increase;

2. Number of cells stays the same for same length of time;

Ignore: wrong days stated

(Differences):

(Per unit volume of blood)

3. Greater / faster decrease in number of healthy cells / more healthy cells

killed / healthy cells killed faster;

Accept: converse for cancer cells

Accept: greater <u>percentage</u> decrease in number of cancer cells / greater <u>proportion</u> of cancer cells killed

4. Greater / faster increase in number of healthy cells / more healthy cells replaced / divide / healthy cells replaced / divide faster;

Accept: converse for cancer cells

*For **differences**, statements made must be comparative*

3 max

(e) 1. More / too many healthy cells killed;

2. (So) will take time to replace / increase in number;

Neutral: will take time to 'repair'

3. Person may die / have side effects;

2 max

[15]

Q2.

(a) 1. Separates / unwinds / unzips strands / helix / breaks H-bonds;

*1. **Q** Neutral: strands / helix split*

1. Accept: unzips bases

2. (So) <u>nucleotides</u> can attach / are attracted / strands can act as templates;

*2. **Q** Neutral: bases can attach*

2. Neutral: helix can act as a template

2

(b)

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

One mark for each correct row

3

(c) (i) 1. Similar shape / structure (to cytosine) / added instead of cytosine / binds to guanine;

1. Accept: idea that <u>only</u> one group is different

1. Reject: same shape

2. Prevents (complementary) base pairing / prevents H-bonds

forming / prevents formation of new strand / prevents strand elongation / inhibits / binds to (DNA) polymerase;

2. Accept: prevents cytosine binding

Neutral: 'prevents DNA replication' as given in the question stem

Neutral: 'competitive inhibitor' unqualified

Neutral: inhibits DNA helicase

2

(ii) (Cancer cells / DNA) divide / replicate fast(er) / uncontrollably;

Accept: converse argument for healthy cells

1

[8]

Q3.

(a) 1. Strands separate / H-bonds break;

*1. **Q** Neutral: strands split*

1. Accept: strands unzip

2. DNA helicase (involved);

3. Both strands / each strand act(s) as (a) template(s);

4. (Free) nucleotides attach;

4. Neutral: bases attach

4. Accept: nucleotides attracted

5. Complementary / specific base pairing / AT <u>and</u> GC;

6. DNA polymerase joins nucleotides (on new strand);

6. Reject: if wrong function of DNA polymerase

7. H-bonds reform;

8. Semi-conservative replication / new DNA molecules contain one old strand and one new strand;

8. Reject: if wrong context e.g. new DNA molecules contain half of each original strand

6 max

(b) (i) 18;

Do not accept 17.5

1

(ii) 10;

1

(iii) 1. Horizontal until 18 minutes;

Allow + / - one small box

2. (Then) decreases as straight line to 0 μm at 28 minutes;

2. Allow lines that start from the wrong place, ending at 0 at 28 minutes

2

(c) (i) Two marks for correct answer of 19.68 or 19.7;;

Accept 19hrs 41mins

One mark for incorrect answers in which candidate clearly multiplies by 0.82;

Allow one mark for incorrect answers that clearly show 82% of 24 (hours)

2

(ii) 1. No visible chromosomes / chromatids / visible nucleus;

1

(iii) **D** (no mark)

1. Lower % (of cells) in interphase / higher % (of cells) in mitosis / named stage of mitosis;

1. Accept: 'less' or 'more' instead of '%'

1. Do not accept: higher % (of cells) in each / all stage(s)

2. (So) more cells dividing / cells are dividing quicker;

2. Accept: uncontrolled cell division

*2. Do not award if Tissue **C** is chosen*

2

[15]

Q4.

(a) (i) Repeating units / nucleotides / monomer / molecules;

Allow more than one, but reject two

1

(ii) 1. C = hydrogen bonds;

2. D = deoxyribose;

Ignore sugar

3. E = phosphate;

Ignore phosphorus, Ignore molecule

3

(iii)

Name of base	Percentage
Thymine	34
Cytosine / Guanine	16
Adenine	34
Cytosine / Guanine	16

Spelling must be correct to gain MP1

First mark = names correct

Second mark = % correct, with adenine as 34%

2

(b) (i) 153;

1

(ii) Some regions of the gene are non-coding / introns / start / stop code / triplet / there are two DNA strands;

Allow addition mutation

Ignore unqualified reference to mutation

Accept reference to introns and exons if given together

Ignore 'junk' DNA / multiple repeats

1

[8]

Q5.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
14 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
6 – 10	Unistructural Only one or few	Response predominantly deals with only one or two topics that relate to the question.

	aspects covered	Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	**Definition**
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
A fully integrated answer which makes clear links between several different topics and the theme of the question	All topics relate to the title and theme of the essay; for example, explaining the biological importance of a process. When considering, for example, the importance of a process, the explanation must be at A-level standard. 'Several' here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic area.
Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting

	and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of shapes fitting together in cells and organisms**.

Topics

Proteins & Enzymes	
3.1.2	Enzyme properties and digestion
3.1.2	Protein structure
3.1.3	Plasma membrane structure and cell transport
3.1.6	Antigens, antibodies, B cells & T cells
3.1.6	Vaccines
Nucleic Acids	
3.2.2	Structure of DNA
3.2.2	DNA Replication (not PCR)
3.5.7	Transcription & translation
3.5.8	Transcriptional factors, oestrogen, siRNA
3.5.8	Restriction enzymes
Physiology	
3.2.4	Haemoglobin

3.5.2	Action potentials & synaptic transmission
3.5.3	Muscle contraction
3.5.4	Control of blood glucose concentration

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q6.

(a) (i) Anaphase

1

(ii) 1. Sister / identical chromatids / identical chromosomes;

Reject: Homologous chromosomes separate.

Allow any reference to chromatids / chromosomes being identical e.g. same DNA

2. To (opposite) poles / ends / sides;

2

(b) (i) 1. 8.4 / cells with twice DNA content = replicated DNA / late interphase / prophase / metaphase / anaphase;

Any reference to interphase must suggest towards end of interphase.

'Chromosomes replicate' is not enough for DNA replicates.

2. 4.2 = DNA not replicated / (early) interphase / telophase / cell just divided / finished mitosis;

2

(ii) 2.1;

1

[6]

Q7.

(a) (i) Spindle formed / chromosome / centromere / chromatids attaches to spindle;

Chromosomes / chromatids line up / move to middle / equator (of cell);

Do not award second mark for answers referring to chromosomes 'pairing up'.

Ignore reference to homologous chromosomes unless context suggests pairing which negates second mark.

Neutral: Details on nuclear membrane.

Accept: Diagram for second marking point.

2

(ii) Chromosome / centromere splits / chromatids / 'chromosomes' separate / pulled apart;

To (opposite) sides / poles / centrioles (of cell);

Reject: Homologous chromosomes separate for first marking point.

Accept: Diagram for second marking point.

Chromatids / 'chromosomes' move to poles / sides / centrioles = 2 marks.

2

(b) (i) Form / replace cells quickly / rapidly / divide / multiply / replicate rapidly;

Neutral: Repair cells.

Answers must convey idea of 'speed'.

1

(Ii) Correct answer = 774 minutes / 12 hours 54mins = 2 marks;;

Incorrect answer but indicates 3 cell cycles involved = one mark;

2

(c) Prevents / slows DNA replication / doubling / prevents / slows mitosis;

New strand not formed / nucleotides (of new strand) not joined together / sugar-phosphate bonds not formed;

First marking point must be in context of DNA replication not cell replication.

Do not negate first marking point if role of DNA polymerase is described incorrectly e.g. Reject: 'joins bases / strands together'.

Role of DNA polymerase must be correct for last marking point.

2

[9]

Q8.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.

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6 – 10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
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For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of Using DNA in science and technology**.

Topics

DNA and classification	
2.2	Structure of DNA
2.3	Differences in DNA lead to genetic diversity
2.9	Comparison of DNA base sequences
Genetic engineering and making useful substances	
2.5	Plasmids
5.8	The use of recombinant DNA to produce transformed organisms that benefit humans
Other uses of DNA	
2.5	Cell cycle and treatment of cancer
5.8	Gene therapy; Medical diagnosis and the treatment of human disease; The use of DNA probes to screen patients for clinically important genes.

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

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[25]

Q9.

(a)

✓	✓	✓	
			✓
		✓	✓

One mark for each correct column

Mark ticks only and ignore crosses

4

(b) 1. Two marks for box round two hydrogens and one of the oxygens from OH groups on carbons 1 and 4;;

2. One mark from incorrect answer involving any two hydrogens and an oxygen from carbons 1 and 4;

Do not award marks if all atoms concerned are on same carbon atom or are on carbon atoms other than 1 and 4 or

where the answer does not have two hydrogen and one oxygen

2

(c) (i) 1. Holds chains / cellulose molecules together / forms cross links between chains / cellulose molecules / forms microfibrils, providing strength / rigidity (to cellulose / cell wall);

2. Hydrogen bonds strong in large numbers;x

Principles here are first mark for where hydrogen bonds are formed and second for a consequence of this.

Accept microfibres

2

(ii) Compact / occupies small space / tightly packed;

Answer indicates depth required. Answers such as "good for storage", "easily stored" or "small" are insufficient.

1

[9]

Q10.

(a)

DNA	✓	2
mRNA	✗	1
tRNA	✓	1

One mark for each correct column
Regard blank as incorrect in the context of this question
Accept numbers written out: two, one, one

2

(b) (i) Marking principles
1 mark for complete piece transcribed;

Correct answer
UGU CAU GAA UGC UAG

1 mark for complementary bases from sequence transcribed;

but allow 1 mark for complementary bases from section transcribed, providing all four bases are involved

2

(ii) Marking principle
1 mark for bases corresponding to exons taken from (b)(i)

Correct answer
UGU UGC UAG
If sequence is incorrect in (b)(i), award mark if section is from exons. Ignore gaps.

1

[5]

Q11.

(a) (i) Deoxyribose;

pentose / 5C sugar = neutral

1

(ii) Phosphate / Phosphoric acid;

phosphorus / P = neutral

1

(b) Hydrogen (bonds);

1

(c) 381 / 384 / 387;

1

(d) (Gln) Met Met Arg Arg Arg Asn;

1

(e) Change in (sequence of) amino acids / primary structure;

Change in hydrogen / ionic / disulfide bonds leads to change in tertiary structure / active site (of enzyme);

Substrate cannot bind / no enzyme-substrate complexes form;

Q *Reject = different amino acids are formed*

3

[8]

Q12.

(a) (i) base / named bases;

reject nucleotide or uracil

1

(ii) it has been produced by semi-conservative replication / one old strand and one new;
One strand has ^{15}N bases and the other ^{14}N;

Accept light / heavy N (therefore) it is less dense / lighter;

2

(iii) one band is in same position as generation 1;
one band higher;
accept a line. N.B. need a visible gap

2

(b) (i) A = 31 and JT = 31;
C = 19;

2

(ii) viral DNA single-stranded / not double-stranded;
evidence from table e.g. not equal amount of A and T / C and G / all different;

2

ignore no base-pairing In this ***Question*** *assume It' means viral DNA*

[9]

Q13.

(a) nucleotide;

1

(b) (i) 21.4, 21.4; 28.6;

2

(ii) amounts of A and T / C and G / complementary bases different;
therefore no base-pairing;

2 max

[5]

Q14.

(a) (i) (Molecule) made up of many identical / similar molecules / monomers / subunits;

Not necessary to refer to similarity with monomers.

1

(ii) Cellulose / glycogen / nucleic acid / DNA / RNA;

1

(b) (i) To keep pH constant;
A change in pH will slow the rate of the reaction / denature the amylase / optimum for reaction;

2

(ii) Purple / lilac / mauve / violet;
Do not allow blue or pink.

1

(iii) Protein present / the enzyme / amylase is a protein;
Not used up in the reaction / still present at the end of the reaction;

2

[7]

Q15.

(i) sugar or phosphate / S-P / nucleotide chain / backbone / original / parent DNA;

1

(ii) X thymine; Y guanine; Z adenine;

(Allow T, G and A) Reject: thiamine

3

[4]

Q16.

(a) Presence of resistant and non-resistant varieties / mutation produces resistant variety;
Resistant ones survive / non-resistant ones killed by treatment;
These will reproduce and produce more resistant parasites / pass on resistance allele;

3

(b) Likelihood of being infected (by strain resistant to both drugs) is less;
1/500 × 1/500/1/250 000;
Drug has longer effective life;

max 2

(c) (i) As comparison / to show that nothing else in the treatment was responsible;

1

(ii) Given injections of saline / injection without SPf66;
(otherwise) treated the same as experimental group;

2

(d) (i) 100%;

1

(ii) 10%;

1

(e) (i) Different lengths of DNA have different base sequences / cut at specific sequence;
Results in different shape / different shape of active site;
Therefore (specific sequence) will only fit active site of enzyme;

3

(ii) Recognition sites contain only AT pairs;
Which would occur very frequently;

2

[15]

Q17.

(a) each strand copied / acts as a template;
(daughter) DNA one new strand and one original / parent strand;

2

(b) (i) ^{15}N / tube **B** (DNA), more / greater density;
(reject heavier)

1

(ii) DNA with one heavy and one light strand;
new / synthesised strand, made with ^{14}N / light strand;

2

(c) 32;
28 32 26;

2

[7]

Q18.

(a) 1 two strands therefore semi-conservative replication (possible);
2 base pairing / hydrogen bonds holds strands together
3 hydrogen bonds weak / easily broken, allow strands to separate;
4 bases (sequence) (exposed so) act as template / can be copied;
5 A with T, C with G / complementary copy;
6 DNA one parent and one new strand;

4 max

(b) 1 chromosomes shorten / thicken / supercoiling;
2 chromosomes (each) two <u>identical</u> chromatids / strands / copies (due to replication);

3 chromosomes / chromatids move to equator / middle of the spindle / cell;
4 attach to individual spindle fibres;
5 spindle fibres contract / centromeres divide / repel;
6 (sister) chromatids / chromosomes (separate) move to opposite poles / ends of the spindle;
7 each pole / end receives all genetic information / identical copies of each chromosome;
8 nuclear envelope forms around each group of chromosomes / chromatids / at each pole;

7 max

(c) cancer cells killed, normal body cells survive;
cancer cells low oxygen (as blood supply cannot satisfy demand);

2

[13]

Q19.

(a) (i) ATA;

1

(ii) AUA;

1

(b) tRNA 'clover leaf' shape; (allow reference to loop / folded structure)
tRNA standard length;
tRNA has an amino acid binding site;
tRNA has anticodon available / three exposed bases;
tRNA has hydrogen bonds (between base pairs);

2 max

[4]

Q20.

(a) different form of a gene;

1

(b) hydrogen bonds broken;
semi-conservative replication / both strands used (as templates);
nucleotides line up complementary / specific base pairing / A and T / C and G;
DNA polymerase;

4

(c) deletion causes frame shift / alters base sequence (from point of mutation);
changes many amino acids / sequence of amino acids (from this point);
substitution alters one codon / triplet / one amino acid altered / code degenerate / same amino acid coded for;

3

[8]

Q21.

(a) appropriately placed box;

1

(b) (i) B;

(ii) A;

2

(c) (i) determines (sequence of) amino acids / specific protein produced / mRNA formation;

1

(ii) hydrogen bonds;

1

(iii) stability / protects bases / replication;

1

[6]

Q22.

(a) **X**, phosphate;
Y, deoxyribose / pentose / 5-carbon sugar;
Z, (nitrogenous) base;
(accept named base)

3

(b) (specific) hydrogen (bonds);

1

(c) thymine 28% so adenine 28%
therefore 44% cytosine and guanine;
therefore 22% cytosine;
(idea of equal amounts T and A, C and G – 1 mark, correct answer 2 marks)

2

[6]

Q23.

(a) (i) substances / molecules have more (kinetic) energy / moving faster;
(reject vibrate)

increased collisions / enzyme substrate complexes formed;

2

(ii) causes denaturation / tertiary structure / shape change / H^+ / ionic bonds break;
(shape) of <u>active site</u> changed;
substrate no longer binds / not complementary to (active site);

3

(b) all substrate changed into product / reaction is complete;
same amount of product formed as same initial substrate concentration;

2

[7]

Q24.

(a) Two suitable differences between DNA and RNA;
1 mark per correct row to 2 max

e.g.

DNA is double stranded, RNA is single stranded;
DNA has thymine present, RNA has Uracil present;

Accept T and U

DNA is larger/heavier/longer, RNA is smaller/lighter/shorter;
DNA has a deoxyribose sugar, RNA has a ribose sugar;
DNA stays in the nucleus, RNA leaves the nucleus;

2 max

(b) Three suitable examples;

e.g.

Carries coded information about the sequence of amino acids;
Copied from DNA/gene;
Code is in sequence of bases / triplet / three bases / a codon codes for one amino acid;
Moves out of nucleus/goes into cytoplasm;
To ribosomes;

Accept codons allow anticodons / tRNA to bind

Accept carries 'start' and 'stop' codes

Accept moves through ribosomes

3 max

[5]

Q25.

(a) (Pentose) sugar/deoxyribose and phosphate;

Reject ribose and phosphorus

1

(b) Semi-conservative replication;
Complementary pairing;
Hydrogen bonding (of bases/nucleotides);
Condensation/described of nucleotides;
DNA polymerase involved;

Accept example (A, T and C, G)

3 max

[4]

Q26.

(a) Any two of:

DNA	RNA
Large molecule	Smaller
Double stranded	Single stranded
Contains Thymine (T)	Contains Uracil (U)
Contains deoxyribose	Contains ribose

2 max

(b) Base sequence (on DNA/in gene);
Determines sequence of amino acids;
By determining base sequence on (messenger) RNA;

Code is a triplet code/three base code for an amino acid;

2 max

(c) Pairs of chromosomes/two chromosomes;
With genes for same features / with same genes;
At same loci / in same sequence;

Accept same alleles

2 max

[6]

Q27.

(a) Decreases by 50%;

Per generation / per division;

Only accessible if linked to first marking point

OR

^{15}N makes up ½ after 1 division;

Makes up ¼ after 2nd division;

2

(b) In DNA replication strands separate;
Each acts as template (for formation of new strand);
One strand in each new molecule / semi-conservative replication;
New strands made using ^{14}N.

2 max

[4]

Q28.

(a) **D** phosphate;
E pentose sugar/deoxyribose;
F (nitrogenous) base/ organic base/ thymine/adenine/ cytosine/guanine;

*In **D** reject phosphorous*

*In **E***

Accept 5-carbon sugar

Reject sugar alone

3

(b)

	DNA	RNA
	double-stranded	single-stranded
	deoxyribose	ribose
	Thymine/T	Uracil/U
	very large/long	very small/short

Accept double helix for DNA

Accept longer and shorter

Need comparison but could be in one box

List rule applies.

2 max

[5]