Q1.

Water and inorganic ions have important biological functions within cells.

(a) Give **two** properties of water that are important in the cytoplasm of cells.
For each property of water, explain its importance in the cytoplasm.

Property 1_____

Biological importance within cells_____

_____

_____

Property 2_____

Biological importance within cells_____

_____

_____

(4)

(b) Other than sodium, name **one** inorganic ion and give **one** example of its biological importance in a cell.

Name of inorganic ion_____

Biological importance_____

_____

_____

(2)

(c) Compare and contrast the processes by which water and inorganic ions enter cells.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

Q2.

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:

Polymers have different structures. They also have different functions. Describe how the structures of different polymers are related to their functions.

(Total 25 marks)

Q3.

Antimicrobial proteins (AMPs), found in the skin of the African clawed frog, can kill bacteria. When AMPs are injected into humans, they are broken down by protease enzymes. Scientists have produced a number of AMPs that are not broken down by proteases. They did this by making these AMPs from man-made amino acids containing fluorine. The AMPs containing fluorine were found to be more effective in killing bacteria than AMPs without fluorine.

(a) Name the type of reaction involved when a protease enzyme breaks down an AMP.

_____

(1)

(b) Suggest why protease enzymes cannot break down AMPs made from amino acids containing fluorine.

_____

_____

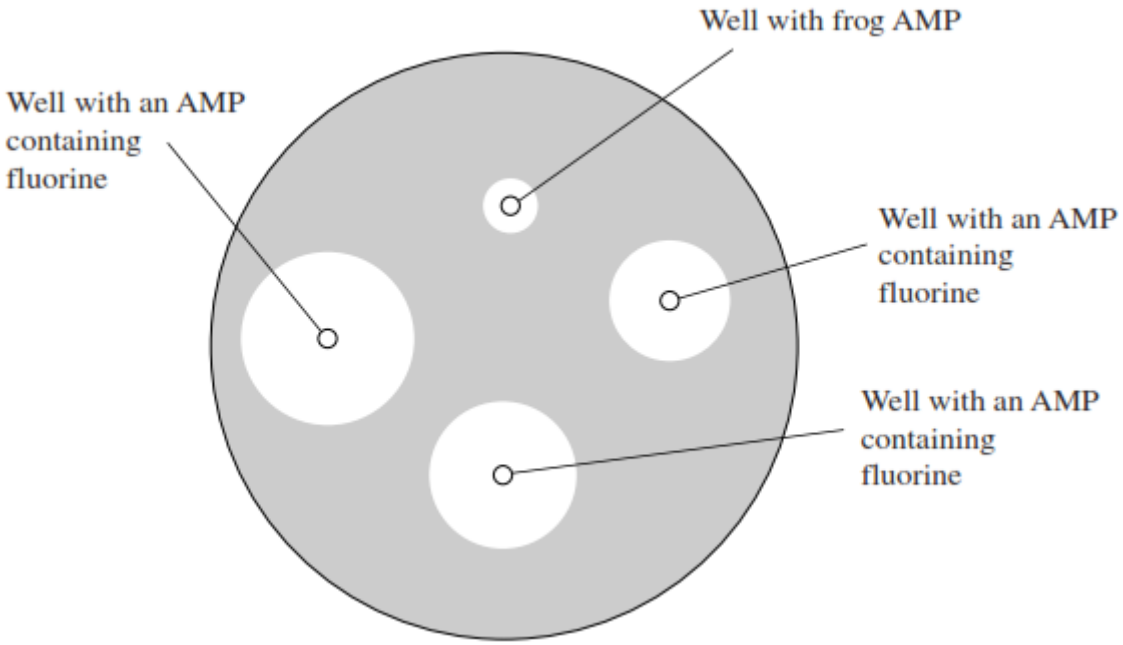
_____

_____

(2)

(c) Scientists carried out an investigation to compare the effectiveness of AMPs containing fluorine and a frog AMP. They inoculated an agar plate with a culture of one species of bacterium. They cut four wells in the agar. They placed a frog AMP in one well. They put three different man-made AMPs containing fluorine in the other three wells. They incubated the plate for 48 hours. After incubation, there were clear areas around each well where the bacteria had not grown.

The appearance of the plate after incubation is shown below.



(i) Give **one** example of aseptic technique that the scientists would have used during this investigation.

_____

_____

(1)

(ii) What conclusions could the scientists draw from these results?

_____

_____

_____

_____

_____

_____

(Extra space) _____

_____

_____

(3)

(Total 7 marks)

Q4.

(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.

_____

_____

_____

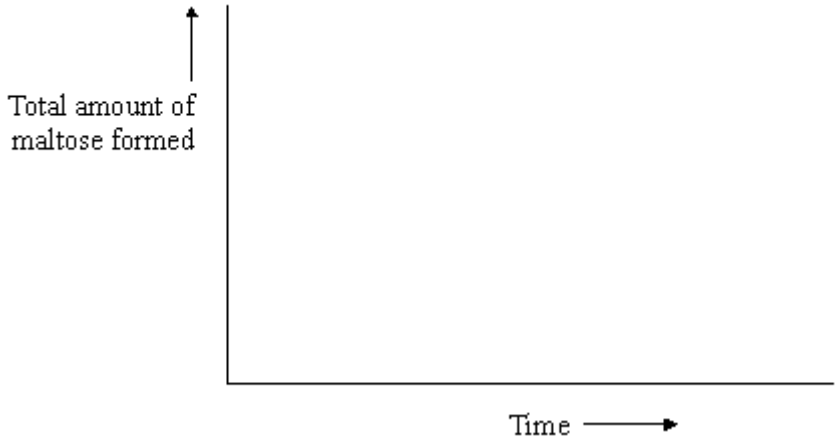
(2)

(Total 13 marks)

Q5.

(a) Amylase is an enzyme which hydrolyses starch to maltose. Some amylase and starch were mixed and the mixture incubated at 37 °C until the reaction was complete.

(i) Sketch a curve on the axes below to show the progress of this reaction.



(1)

(ii) Explain why the rate of the reaction decreases as the reaction progresses.

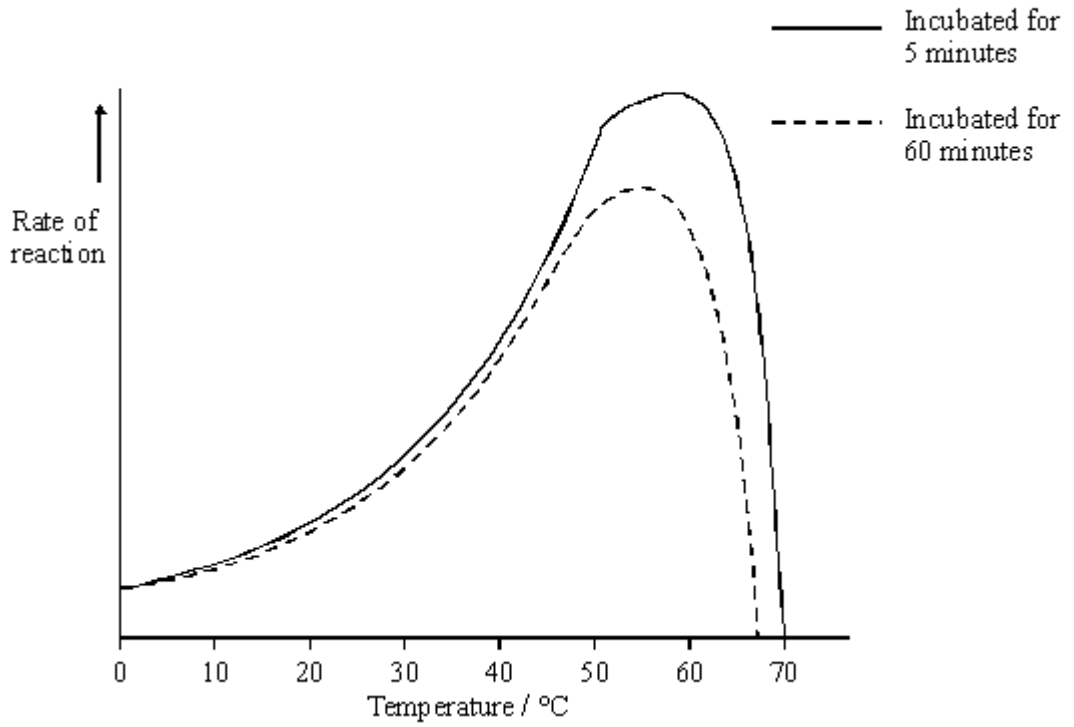
_____

_____

_____

(2)

The effect of temperature on the rate of reaction of an enzyme was investigated. A test tube containing the enzyme and a test tube containing the substrate were incubated separately at each of the temperatures being investigated. After 5 minutes, they were mixed and the rate of reaction was determined. The experiment was repeated but, this time, the enzyme and the substrate were left for 60 minutes before they were mixed. The results of the investigation are shown in the graph.



(b) The enzyme solution used in this investigation was made by dissolving a known mass of enzyme in a buffer solution. Explain why a buffer solution was used.

_____

_____

(1)

(c) (i) Use the graph to describe how incubation time affects the rate of the reaction.

_____

_____

_____

_____

(2)

(ii) The maximum rate of reaction with an incubation time of 60 minutes is less than the maximum rate of reaction with an incubation time of 5 minutes. Explain why.

_____

_____

_____

_____

_____

(3)

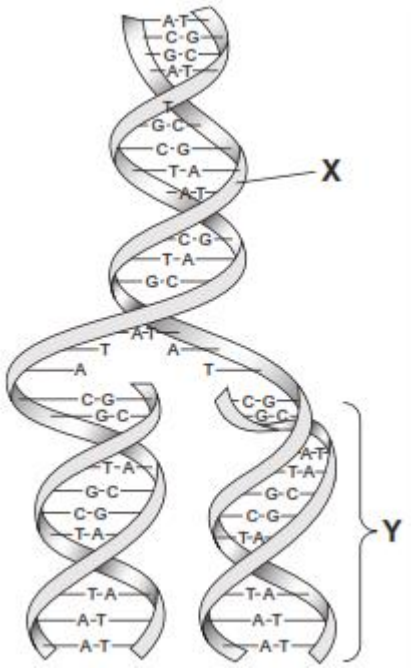
(d) Explain how inhibitors affect the rate of enzyme-controlled reactions.

(6)

(Total 15 marks)

Q6.

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*) _____

_____

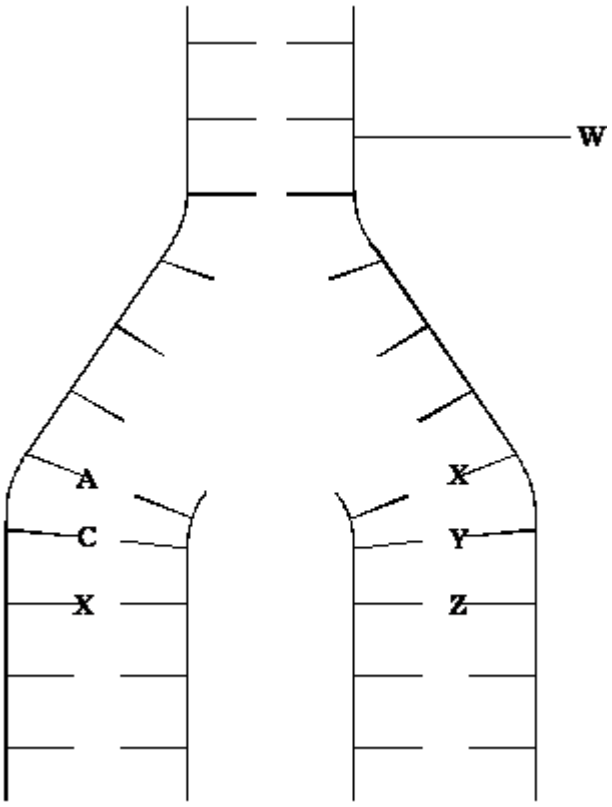
_____

(3)

(Total 4 marks)

Q7.

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)

Q8.

The bases in DNA nucleotides contain nitrogen.

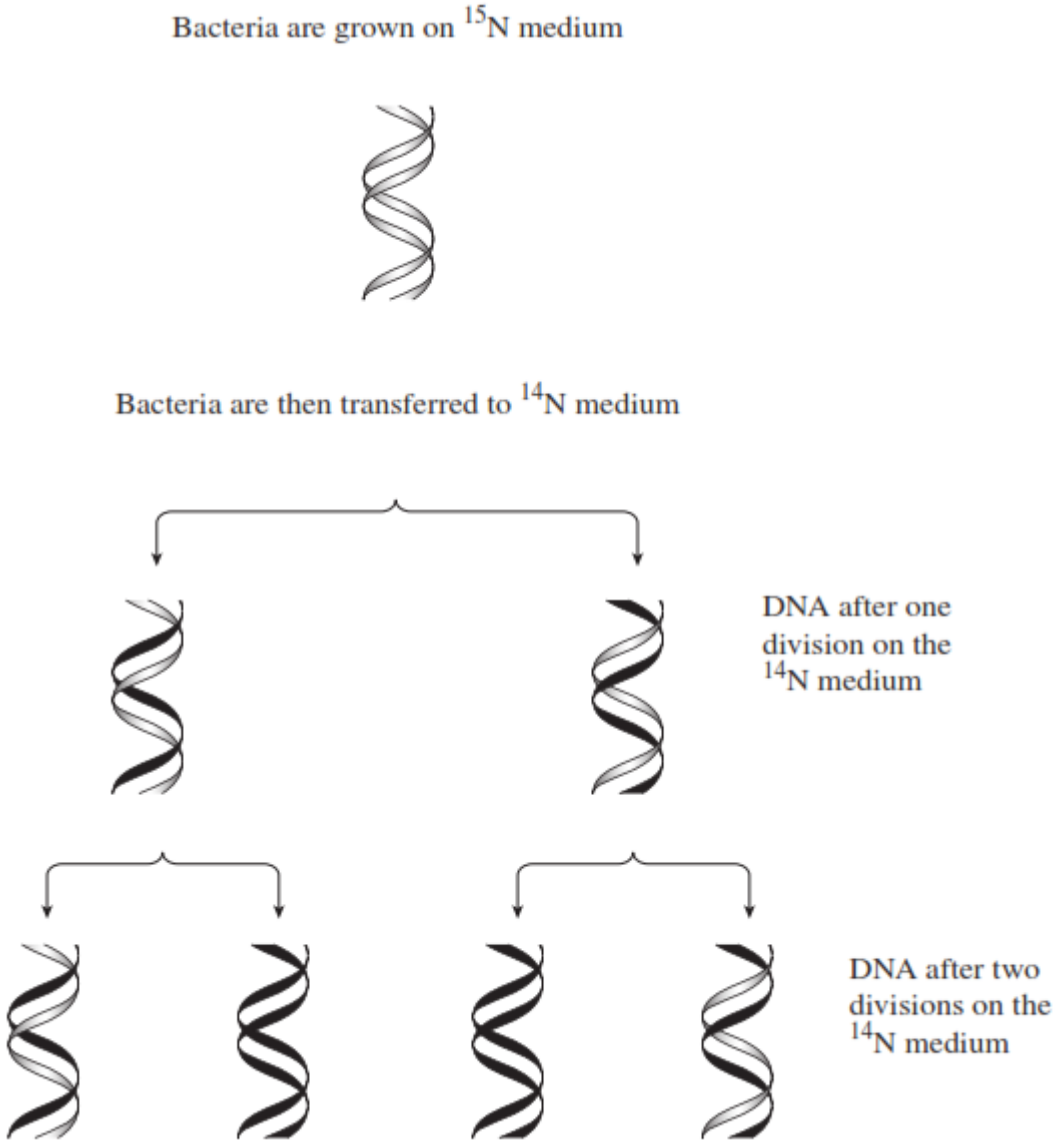
Researchers grew bacteria on a medium containing ^{15}N ('heavy' nitrogen) for several generations. They then transferred the bacteria to a medium containing ^{14}N ('ordinary' nitrogen). They analysed DNA from the bacteria at three stages:

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.



(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)

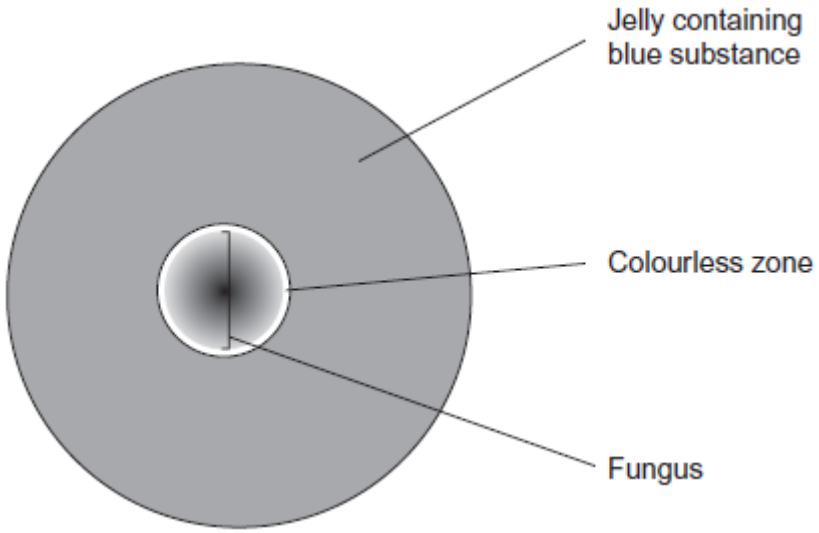
Q9.

Catalase is used in a number of industrial processes. It is normally obtained from a fungus called *Aspergillus niger*. Scientists produced a mutant strain of *A. niger* called K30. They wanted to know if this mutant strain produced more catalase than the normal strain of *A. niger*.

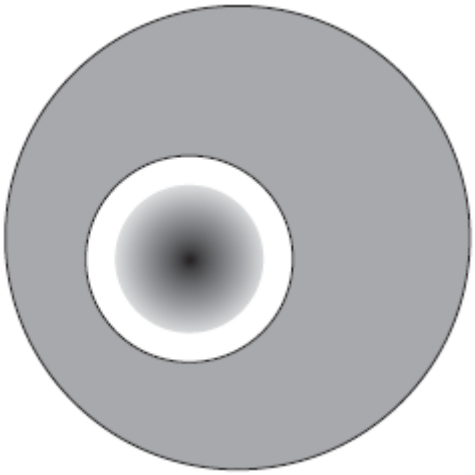
- The scientists grew samples of the normal strain of the fungus and of the K30 strain on jelly in separate Petri dishes. The jelly contained a blue substance which is turned colourless by catalase.
- They incubated the dishes for 3 days then measured the diameter of the colourless zone around the fungus.
- They calculated the ratio of the diameter of the colourless zone to the diameter of the fungus.

The diagram shows the dishes after incubation.

Normal strain



K30 strain



(a) The scientists grew both strains of fungi on dishes kept at 30 °C. Keeping the dishes at a temperature of 15 °C would affect the results. Use your knowledge of kinetic energy to explain why.

_____

_____

_____

_____

_____

(2)

(b) (i) The scientists gave their results as ratios. Explain the advantage of giving the results of this investigation as a ratio.

_____

_____

_____

_____

_____

(2)

(ii) For the normal strain the ratio of the diameter of the colourless zone to the diameter of the fungus was 1.1 : 1.

Calculate the ratio of the diameter of the colourless zone to the diameter of the fungus for the K30 strain. Show your working.

Ratio = _____

(2)

(c) The catalase produced by the K30 strain of the fungus is mainly an extracellular enzyme. This means that the fungus secretes catalase from its cells into the jelly in the Petri dish.

Describe and explain the evidence from the investigation which shows that the catalase is an extracellular enzyme.

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q10.

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)

Q11.

Haemoglobin is a protein. It is made of two alpha polypeptides and two beta polypeptides. Each alpha polypeptide has 141 amino acids and each beta polypeptide has 146 amino acids.

(a) What term is used to describe the structure of a protein made of two or more polypeptides?

_____

(1)

(b) Calculate the minimum number of DNA bases needed to code for the number of amino acids in one alpha polypeptide.

Answer = _____

(1)

(c) Describe the role of haemoglobin in supplying oxygen to the tissues of the body.

_____

_____

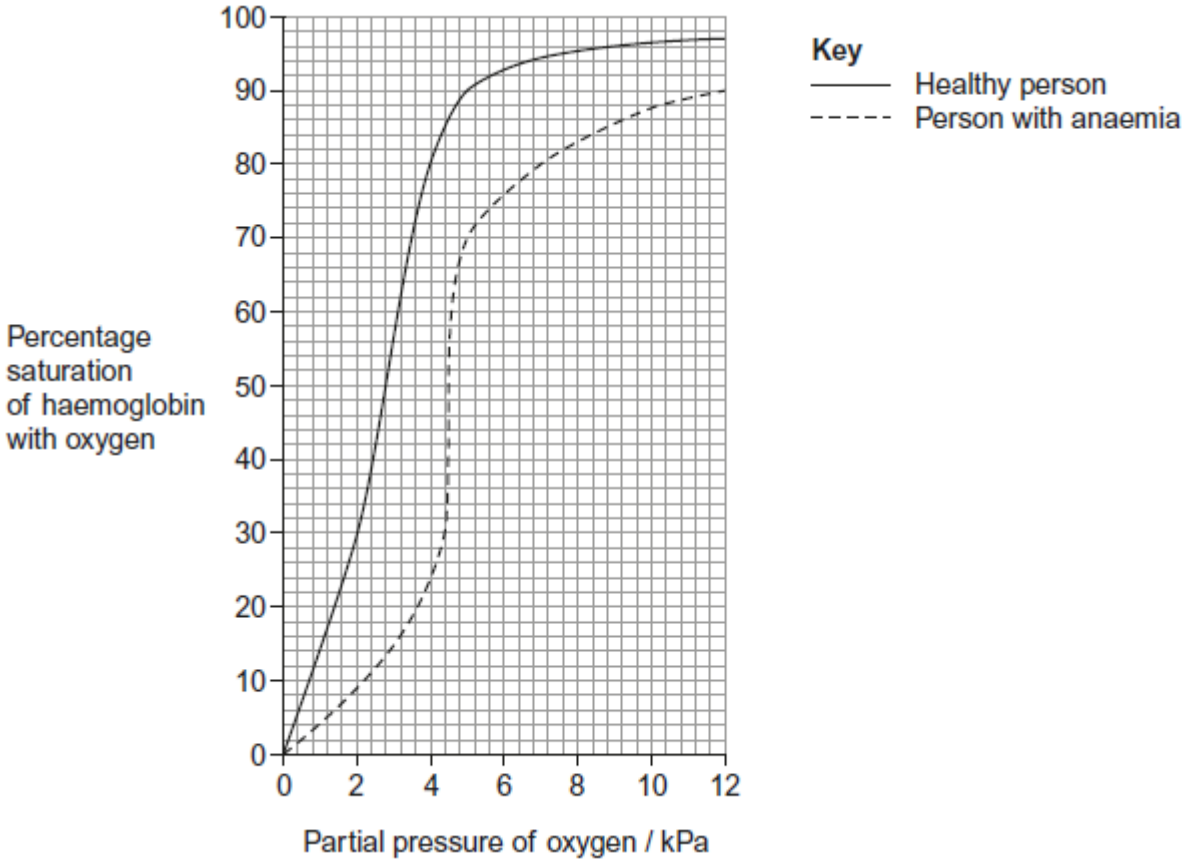
_____

_____

(2)

Anaemia is a condition in which there is a decrease in the concentration of haemoglobin in blood. In some people with anaemia, substances are produced which change the oxygen dissociation curve of haemoglobin.

The graph shows the effect of these substances on the oxygen dissociation curve of haemoglobin.



(d) (i) Use information in the graph to find the difference in the percentage saturation of haemoglobin with oxygen between a healthy person and a person with anaemia at a partial pressure of oxygen of 4 kPa.

Answer = _____

(1)

(ii) Explain the advantage to a person with anaemia of the change shown in the oxygen dissociation curve.

_____

_____

_____

_____

_____

_____

_____

(3)

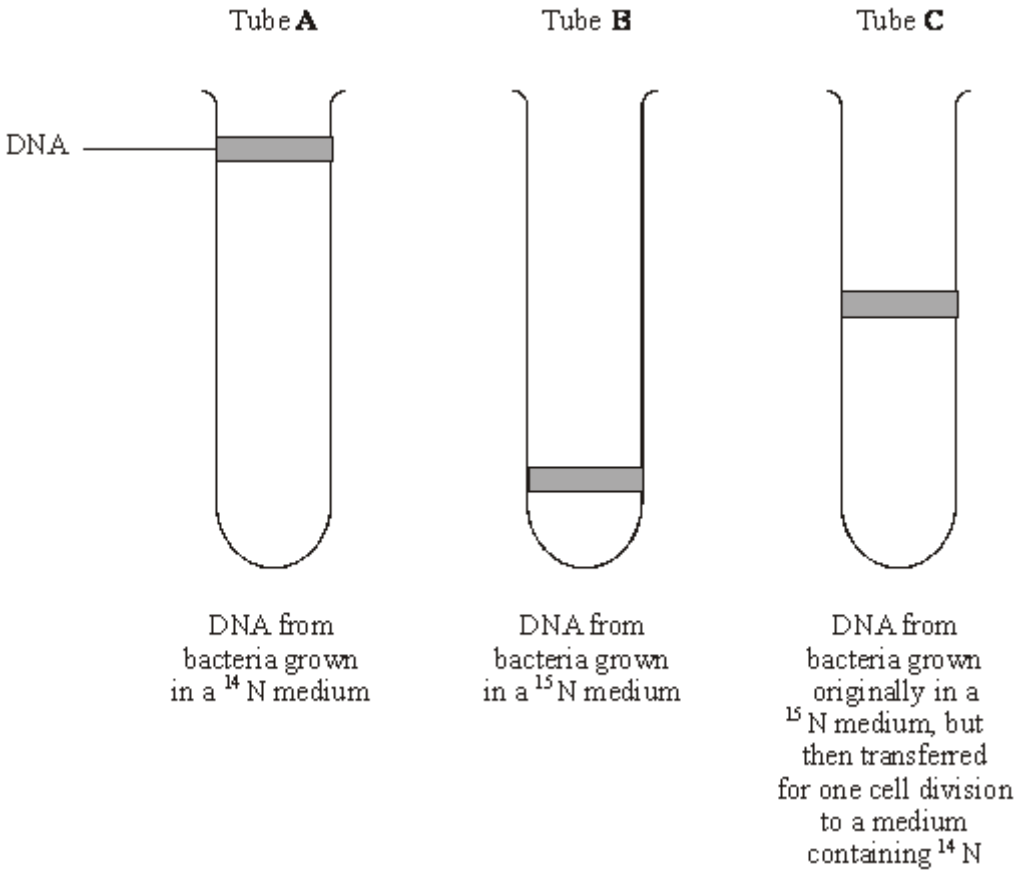
(Total 8 marks)

Q12.

(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)

Q1.

(a) 1. Polar molecule;

2. Acts as a (universal) solvent;

OR

3. (Universal) solvent;

4. (Metabolic) reactions occur faster in solution;

OR

5. Reactive;

6. Takes place in hydrolysis / condensation / named reaction;

Polar molecule so acts as (universal) solvent so (metabolic reactions are faster = 3 marks

4

(b) Name of ion;

Correct function within cell;

Ions other than sodium in specification are H^+, Fe^{2+} and PO_4^{3-} but accept any correct ion (other than sodium) plus relevant function = 2.

Allow ion to be named in words but not as element, e.g, iron ion but not iron.

2

(c) 1. Comparison: both move down concentration gradient;

2. Comparison: both move through (protein) channels in membrane;

Accept aquaporins (for water) and ion channels

3. Contrast: ions can move against a concentration gradient by active transport

3

[9]

Q2.

General principles for marking the Essay:

Four skill areas will be marked: scientific content, breadth of knowledge, relevance and quality of language. The following descriptors will form a basis for marking.

Scientific content (maximum 16 marks)

Category	Mark	Descriptor
	16	
Good	14	Most of the material of a high standard reflecting a comprehensive understanding of the principles involved

		and a knowledge of factual detail fully in keeping with a programme of A-level study. Some material, however, may be a little superficial. Material is accurate and free from fundamental errors but there may be minor errors which detract from the overall accuracy.
	12	
	10	
Average	8	A significant amount of the content is of an appropriate depth, reflecting the depth of treatment expected from a programme of A-level study. Generally accurate with few, if any fundamental errors. Shows a sound understanding of most of the principles involved.
	6	
	4	
Poor	2	Material presented is largely superficial and fails to reflect the depth of treatment expected from a programme of A-level study. If greater depth of knowledge is demonstrated, then there are many fundamental errors.
	0	

Topics

3.1.1 Monomers and polymers

3.1.2 Carbohydrates

3.1.4 Proteins

3.1.5 Nucleic acids

3.2.3 transport across membranes

3.2.4 Cell recognition and the immune system

3.3.3 Digestion and absorption

3.4.1 DNA, genes and chromosomes

Breadth of Knowledge (maximum 3 marks)

Mark	Descriptor
3	A balanced account making reference to most if not all areas that might realistically be covered on an A-level course of study.
2	A number of aspects covered but a lack of balance. Some topics essential to an understanding at this level not covered.
1	Unbalanced account with all or almost all material based on a single aspect
0	Material entirely irrelevant.

Relevance (maximum 3 marks)

Mark	Descriptor
3	All material presented is clearly relevant to the title. Allowance should be made for judicious use of introductory material

2	Material generally selected in support of title but some of the main content of the essay is of only marginal relevance.
1	Some attempt made to relate material to the title but considerable amounts largely irrelevant.
0	Material entirely irrelevant or too limited in quantity to judge.

Quality of language (maximum 3 marks)

Mark	Descriptor
3	Material is logically presented in clear, scientific English. Technical terminology has been used effectively and accurately throughout.
2	Account is logical and generally presented in clear, scientific English. Technical terminology has been used effectively and is usually accurate.
1	The essay is generally poorly constructed and often fails to use an appropriate scientific style and terminology to express ideas.
0	Material entirely irrelevant or too limited in quantity to judge.

[25]

Additional notes on marking this question

Care must be taken in using these notes. It is important to appreciate that the only criteria to be used in awarding marks to a particular essay are those corresponding to the appropriate descriptors. Candidates may gain credit for any information providing that it is biologically accurate, relevant and of a depth in keeping with an A-level course of study. Material used in the essay does not have to be taken from the specification, although it is likely that it will be.

These notes must therefore be seen merely as guidelines providing an indication of areas of the specification from which suitable factual material might be drawn.

In determining the mark awarded for breadth, content should ideally come from each of the areas specified if maximum credit is to be awarded. Where the content is drawn from two areas, two marks should be awarded and where it is taken only from a single area, one mark should be awarded. However, this should only serve as a guide. This list is not exhaustive and examiners should be prepared to offer credit for the incorporation of relevant material from other areas of study.

Q3.

(a) Hydrolysis;

Accept breaking of peptide bonds

1

(b) Adding fluorine changes shape/different shape from other proteins;
Do not fit active site (of protease);
Induced fit not produced;

2 max

(c) (i) Suitable example;
e.g. Flaming spreader/ use lid of Petri dish as umbrella/ clean bench with disinfectant/ sterilise agar in autoclave;

Ignore references to wearing gloves, unless suitably qualified and unqualified references to 'clean'

1

(ii) All the AMPs killed/inhibited the bacteria/AMPs with fluorine more effective than frog AMP;
Not All fluorine AMPs are equally effective;
Diameter/area of clear zone indicates effectiveness;
Only used one kind of bacterium/need to repeat using other bacteria;
Need to repeat the investigation/only one plate used;
Credit suitable measurements or calculations;

3 max

[7]

Q4.

(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 identical 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]

Q5.

(a) (i) Curve rising and levelling out;

1

(ii) Substrate becomes limiting / falls / gets less;
Fewer collisions / complexes formed;

2

(b) To keep pH the same / optimum pH / so change in pH does not affect reaction;

1

(c) (i) For temperature up to 40 – 50 °C has no effect;
Over temperature (of 40 – 50 °C) reduces rate of reaction;

Note. Award one mark for general statement about the longer the incubation time, the slower the rate of reaction.

2

(ii) Bonds (holding tertiary structure) broken;
More enzyme denatured / tertiary structure destroyed / active sites lose shape / no longer fit;
Fewer enzyme-substrate complexes formed;

Note. Award marks if clearly in the context of more denaturation. Allow credit here for converse relating to exposure for 5 minutes.

3

(d) Competitive
2 Similarity of shape of inhibitor and substrate;
3 Inhibitor can enter / bind with active site (of enzyme);

Non-competitive
4 Affect / bind to enzyme other than at active site;
5 Distorts shape of active site;

Inhibitors
6 Prevent entry of / binding of substrate to active site;
7 Therefore fewer / no enzyme-substrate complexes formed;

6

[15]

Q6.

(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]

Q7.

(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]

Q8.

(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]

Q9.

(a) ***EITHER***

Answer either based on

1. Molecules move at slower speeds;

2 diffusion or

2. Decreases rate of diffusion;

4 enzymes.

OR

3. Molecules move at slower speed;

4. Fewer collisions between enzymes and substrates / fewer enzyme-substrate complexes formed;

Accept converse answers if clearly in context of "If it stayed at 30 C".

2 max

(b) (i) 1. Allows comparison;
2. Different amounts of fungus added / fungus is different size at start;

2

(ii) Two marks for correct answer in range 1.7 : 1 to 1.3 : 1;;

Answer must be expressed this way round and must give the diameter of the fungus as 1.

One mark for unsimplified answer in range 29 : 19 to 27 : 21;

Calculations are based on tolerance limits for measurements of ± 1 mm. If the actual measurements are other than 28 and 20, marking guidelines should be adjusted accordingly.

2

(c) 1. Colourless zone around fungus / colourless zone outside fungus;

2. No fungus growing here / must be enzyme here;

Accept any alternative wording clearly relating to colourless zone.

2

[8]

Q10.

(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]

Q11.

(a) Quaternary (structure);

Accept phonetic spelling eg quarternary/quarternery /4°

Award no mark for quaternary as part of a list

1

(b) 423;

1

(c) 1. Oxyhaemoglobin formed/ haemoglobin is loaded/ uptakes/associates/binds with oxygen in area of higher ppO_2 / in gas exchange surface/lungs/gills;

Reference to "react with" = max 1

Accept: reversible interaction with oxygen

Ignore: haemoglobin is carried / contained in red blood cells

2. (oxygen) unloaded/dissociates from/released (in area of lower ppO_2 / in capillaries/to cells/tissues);

2

(d) (i) 56(%);

Accept responses in the range 54-58(%)

1

(ii) 1. (Anaemia curve shifted to right) haemoglobin has lower affinity for oxygen / binds less tightly;

Assume reference is to haemoglobin of anaemia unless stated

2. releases more oxygen / oxygen is released quicker / oxygen dissociates/ unloads more readily to muscles/tissues/cells;

3. (For) respiration;

Accept: even with a lower haemoglobin concentration / meet demand for ATP/energy;

3

[8]

Q12.

(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]