

Please check the examination details below before entering your candidate information

Candidate surname <i>StemUp Model Solution</i>		Other names											
Pearson Edexcel Level 3 GCE		Centre Number <table border="1"><tr><td></td><td></td><td></td><td></td><td></td></tr></table>						Candidate Number <table border="1"><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
Tuesday 19 May 2020													
Afternoon (Time: 1 hour 30 minutes)		Paper Reference 8BI0/01											
Biology B Advanced Subsidiary Paper 1: Core Cellular Biology and Microbiology													
You must have: Calculator, HB pencil, ruler			Total Marks										

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You may use a scientific calculator.
- In question(s) marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

- 1** Short sequences of nucleotides are being developed as potential drugs.

They act by binding to selected sites on DNA or RNA molecules and prevent the synthesis of a specific protein associated with a disease.

Two types of drug to treat genetic disorders are:

- antisense drugs, which are RNA nucleotides that bind to mRNA
- triplex drugs, which are DNA nucleotides that bind to DNA forming a three-stranded helix.

- (a) (i) The type of bonds that hold the two strands of a DNA molecule together in a double helix are

(1)

- ☐ **A** glycosidic bonds
- ☒ **B** hydrogen bonds
- ☐ **C** phosphodiester bonds
- ☐ **D** peptide bonds

- (ii) Antisense drugs inhibit protein synthesis by interfering with

(1)

- ☐ **A** protein folding
- ☐ **B** replication
- ☐ **C** transcription
- ☒ **D** translation

- (iii) Triplex drugs inhibit protein synthesis by interfering with

(1)

- ☐ **A** protein folding
- ☐ **B** replication
- ☒ **C** transcription
- ☐ **D** translation

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(b) The table shows the sequence of bases in part of an mRNA molecule.

Complete the table to show the base sequence of **each** of the following:

(i) the corresponding coding strand of DNA that produced this mRNA sequence

(1)

(ii) the base sequence of an antisense drug that will bind to this mRNA.

(1)

Base sequence on the DNA coding strand	G	T	A	C	G	T	A	T	A	G	C	C
Base sequence on mRNA	C	A	U	G	C	A	U	A	U	C	G	G
Base sequence of antisense drug	G	U	A	C	G	U	A	U	A	G	C	C

(iii) State the number of amino acids that would be coded for by the part of mRNA shown in this table.

(1)

4 amino acids (12 bases = 4 codons, 3 bases per codon).

(c) Which of the following statements is true for the total number of bases in a double-stranded DNA molecule?

(1)

☐ A $\frac{A + T}{C + G} = 1$

☒ B $\frac{A}{T} = \frac{C}{G}$

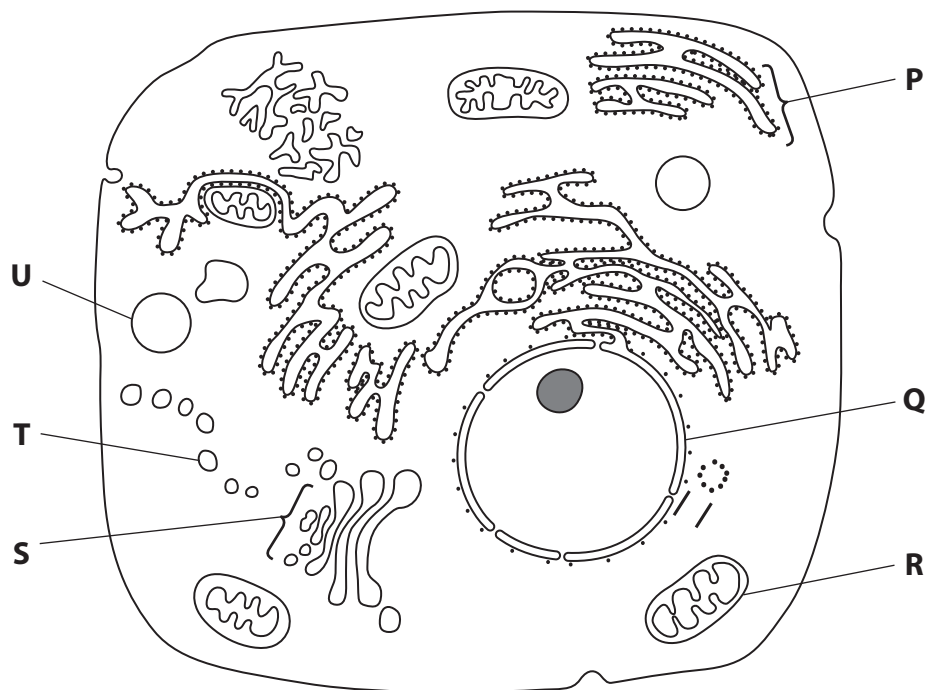
☐ C $A \times T = C \times G$

☐ D $\frac{A}{C} = \frac{G}{T}$

(Total for Question 1 = 7 marks)



2 The diagram shows the ultrastructure of an animal cell.



Magnification $\times 9000$

(a) (i) The structure labelled **R** on the diagram represents a

(1)

- ☐ **A** chloroplast
- ☐ **B** lysosome
- ☒ **C** mitochondrion
- ☐ **D** ribosome

(ii) The structure labelled **Q** on the diagram represents the

(1)

- ☐ **A** cell surface membrane
- ☒ **B** nuclear envelope
- ☐ **C** rough endoplasmic reticulum
- ☐ **D** smooth endoplasmic reticulum

(iii) Calculate the actual diameter of the structure labelled **U**.

(2)

$$\text{diameter of U on diagram} = 8 \text{ mm}$$

$$\text{actual size} = \text{image} \div \text{magnification} = 8 \div 9000$$

$$= 0.00089 \text{ mm}$$

Answer 0.89 μm



(iv) Describe how the structures labelled **P**, **S** and **T** are involved in the production and secretion of molecules from this cell.

(3)

P is the rough endoplasmic reticulum: its ribosomes are where translation (protein synthesis) takes place, and the proteins are transported through the RER.

S is the Golgi apparatus: the proteins are received from the RER and are modified, sorted and packaged here (e.g. quaternary structure produced, carbohydrate added).

T are vesicles: they bud off the Golgi apparatus and transport the proteins (e.g. enzymes) to the cell surface membrane, where they fuse with it and release the proteins by exocytosis.

(b) Which row in the table is correct for structures found in animal cells and prokaryotic cells?

(1)

	Nucleolus		Plasmid		Ribosome	
	Animal cell	Prokaryotic cell	Animal cell	Prokaryotic cell	Animal cell	Prokaryotic cell
☐ A	✓	×	✓	✓	✓	✓
☐ B	×	✓	✓	✓	×	✓
☒ C	✓	×	×	✓	✓	✓
☐ D	✓	✓	✓	×	✓	×



P 6 2 3 0 4 A 0 5 2 8

- (c) Explain why it is possible to see the detailed structure of a prokaryotic cell with an electron microscope but not with a light microscope.

(2)

Light has a longer wavelength than electrons (an electron beam has a much shorter wavelength).

Therefore a light microscope has a lower resolution than an electron microscope, so the small organelles in a prokaryotic cell cannot be distinguished as separate structures.

(Total for Question 2 = 10 marks)



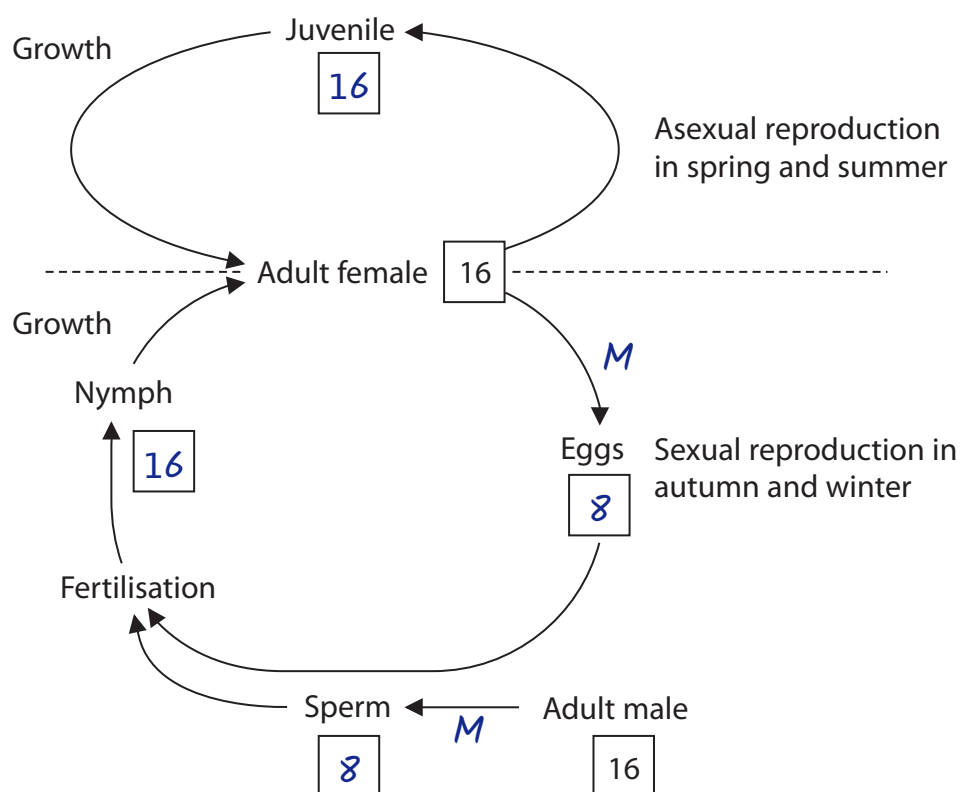
- 3 Adult female cabbage aphids (*Brevicoryne brassicae*) undergo either asexual reproduction or sexual reproduction depending on the time of year.

The photograph shows some cabbage aphids on a cabbage leaf.



Source: © Denis Crawford/Alamy Stock Photo

Some of the boxes in the diagram show the number of chromosomes present in a single cell from a particular stage of each of the alternative methods of reproduction.



- (a) (i) Complete the empty boxes in the diagram to show the number of chromosomes present in a single cell at that stage of reproduction.

(2)

- (ii) Label the arrows on the diagram with the letter **M** to show where meiosis takes place.

(1)



(b) Explain why a juvenile aphid is genetically identical to its parent.

(3)

The juvenile is produced by asexual reproduction, which occurs by mitosis.

Before mitosis DNA replication takes place, producing identical sister chromatids, and mitosis divides the sister chromatids equally into each new cell.

So the cells receive identical chromosomes from only one parent, and there is no crossing over, independent assortment or random fusion of gametes, so there is no genetic variation.

(c) (i) Complete the table with a ✓ or ✗ to compare the events during mitosis and meiosis. The first row in the table has been completed for you.

(3)

Event	Mitosis	Meiosis I	Meiosis II
chromosomes shorten and thicken	✓	✓	✗
homologous chromosomes pair together	✗	✓	✗
crossing over can cause genetic variation	✗	✓	✗
homologous chromosomes separate	✗	✓	✗
sister chromatids separate	✓	✗	✓



(ii) Which of the following increases the number of different alleles in a population? (1)

- ☐ A crossing over
- ☒ B gene mutation
- ☐ C independent assortment of chromosomes during nuclear division
- ☐ D random fusion of gametes

(Total for Question 3 = 10 marks)

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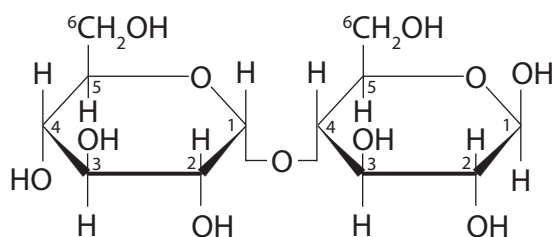
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P 6 2 3 0 4 A 0 9 2 8

4 Enzymes are involved in a wide range of metabolic reactions.

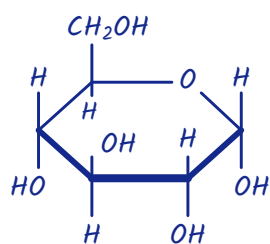
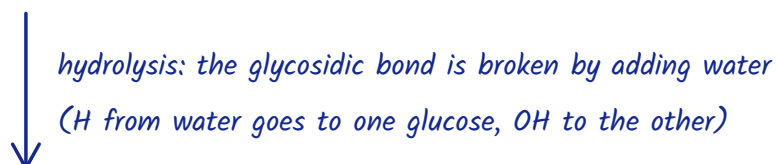
(a) The diagram represents the structure of a maltose molecule.



Draw a diagram to show the hydrolysis of maltose.

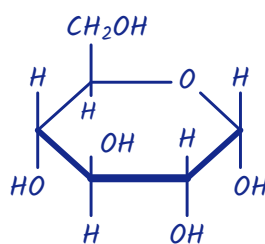
(3)

maltose + water (H₂O)



α-glucose

+



α-glucose

maltose + H₂O → glucose + glucose (two molecules of α-glucose)

(b) Catalase is an enzyme found in potato cells.

It catalyses the breakdown of hydrogen peroxide.

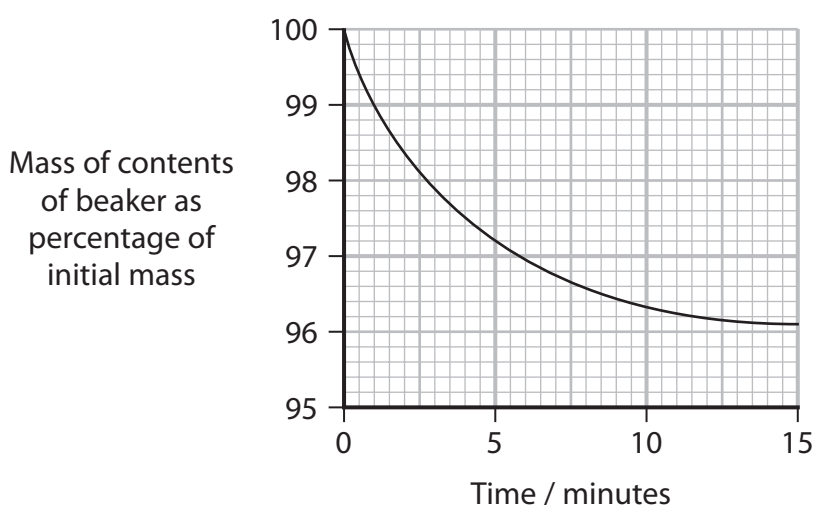


In an investigation, cylinders of potato were cut with a cork borer.

The cylinders were then sliced into discs with the same thickness and put into a small beaker containing 50 cm³ of hydrogen peroxide.

The mass of the beaker and its contents was recorded over a period of 15 minutes.

The graph shows the results of the experiment.



Explain the relationship shown in the graph.

(4)

The mass of the contents of the beaker decreases over time, from 100% to about 96% after 15 minutes.

This is because catalase breaks down hydrogen peroxide into water and oxygen, and the oxygen is a gas that is released (lost) from the beaker.

The rate of decrease in mass is non-linear: the loss of mass is fastest at the start and slows down over time, levelling off, so the rate of reaction decreases.

This is because the substrate (hydrogen peroxide) is used up, so the substrate concentration becomes lower.

This results in fewer collisions between the active site of catalase and the substrate, so fewer enzyme-substrate complexes form.



- (c) Explain how a gene mutation can prevent the production of catalase in potato cells.

(3)

A gene mutation is a change in the sequence of bases in the DNA, e.g. a substitution, a deletion causing a frameshift, or an insertion.

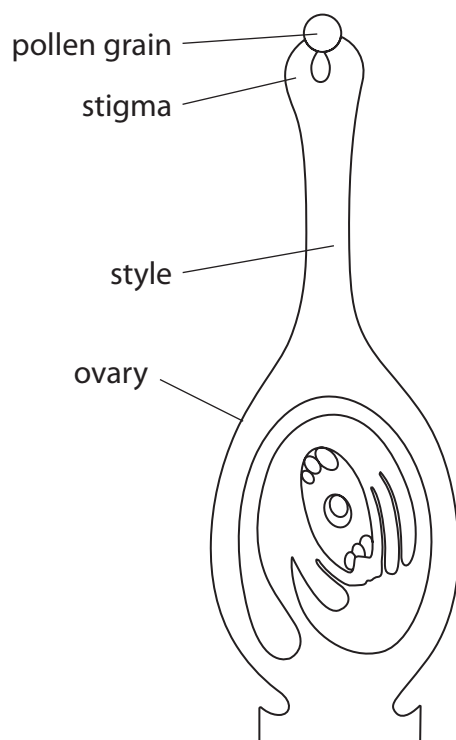
This results in a different or missing codon, so a different or missing amino acid, or a stop codon may be formed early (or the start codon lost), so the primary structure (amino acid sequence) changes.

This results in a different, shorter or missing protein, so the enzyme catalase is not produced (or does not fold into a functional enzyme with the correct active site).

(Total for Question 4 = 10 marks)



5 The diagram illustrates part of a flowering plant when pollination has just taken place.



(a) Describe the role of enzymes in the growth of the pollen tube.

(3)

Enzymes (secreted by the pollen tube) hydrolyse (digest) the tissue of the style.

The products of digestion provide nutrients and energy (ATP via aerobic respiration) for pollen tube growth.

Digestion clears a path through the style for the pollen tube to grow down, and allows the pollen tube to enter the ovule through the micropyle.



- (b) The styles of some plants secrete RNAase enzymes when pollen from the same flower germinates on the stigma.

Explain how these RNAase enzymes affect the growth of the pollen tube.

(3)

The RNAase enzymes hydrolyse (digest) the mRNA in the pollen tube.

This prevents translation, so protein synthesis (enzyme synthesis) cannot take place.

So the enzymes needed to digest the style are not made, which prevents pollen tube growth and the pollen tube reaching the ovule, so self-pollination (self-fertilisation) is prevented.

- (c) Explain the role of double fertilisation in flowering plants.

(4)

Two male nuclei from the pollen tube enter the embryo sac in the ovule.

One male nucleus fuses with the two polar nuclei, which produces a triploid ($3n$) endosperm nucleus.

The endosperm therefore provides nutrients (a food store) for the developing embryo and for germination of the seed.

The other male nucleus fuses with the female gamete (egg cell) nucleus, which produces the diploid zygote, which develops into the embryo.

(Total for Question 5 = 10 marks)



6 Male fertility can be determined by a number of different factors.

(a) Describe the process of spermatogenesis.

(4)

Germ cells (in the seminiferous tubules) divide by mitosis to form spermatogonia, which grow into diploid primary spermatocytes.

Primary spermatocytes divide by meiosis (first meiotic division) to form two haploid secondary spermatocytes.

The second meiotic division forms haploid spermatids.

The spermatids develop (differentiate) into mature spermatozoa (sperm), which includes forming an acrosome and a flagellum.

(b) The mean volume of the semen produced by a male ejaculation is 3.4 cm^3 .

This contains a mean concentration of $17\,000 \text{ sperm mm}^{-3}$.

Calculate the mean total number of sperm in a single ejaculation.

Give your answer in standard form.

(2)

$$3.4 \text{ cm}^3 = 3.4 \times 1000 = 3400 \text{ mm}^3$$

$$\text{total} = 3400 \times 17\,000 = 57\,800\,000$$

$$= 5.78 \times 10^7$$

Answer 5.8×10^7



- (c) The distance from the point of ejaculation in the vagina to the upper end of the fallopian tube (where fertilisation takes place) is 19 cm.

Some sperm travel this distance in three hours.

Calculate the mean speed of these sperm in cm min^{-1} .

(1)

$$3 \text{ hours} = 3 \times 60 = 180 \text{ minutes}$$

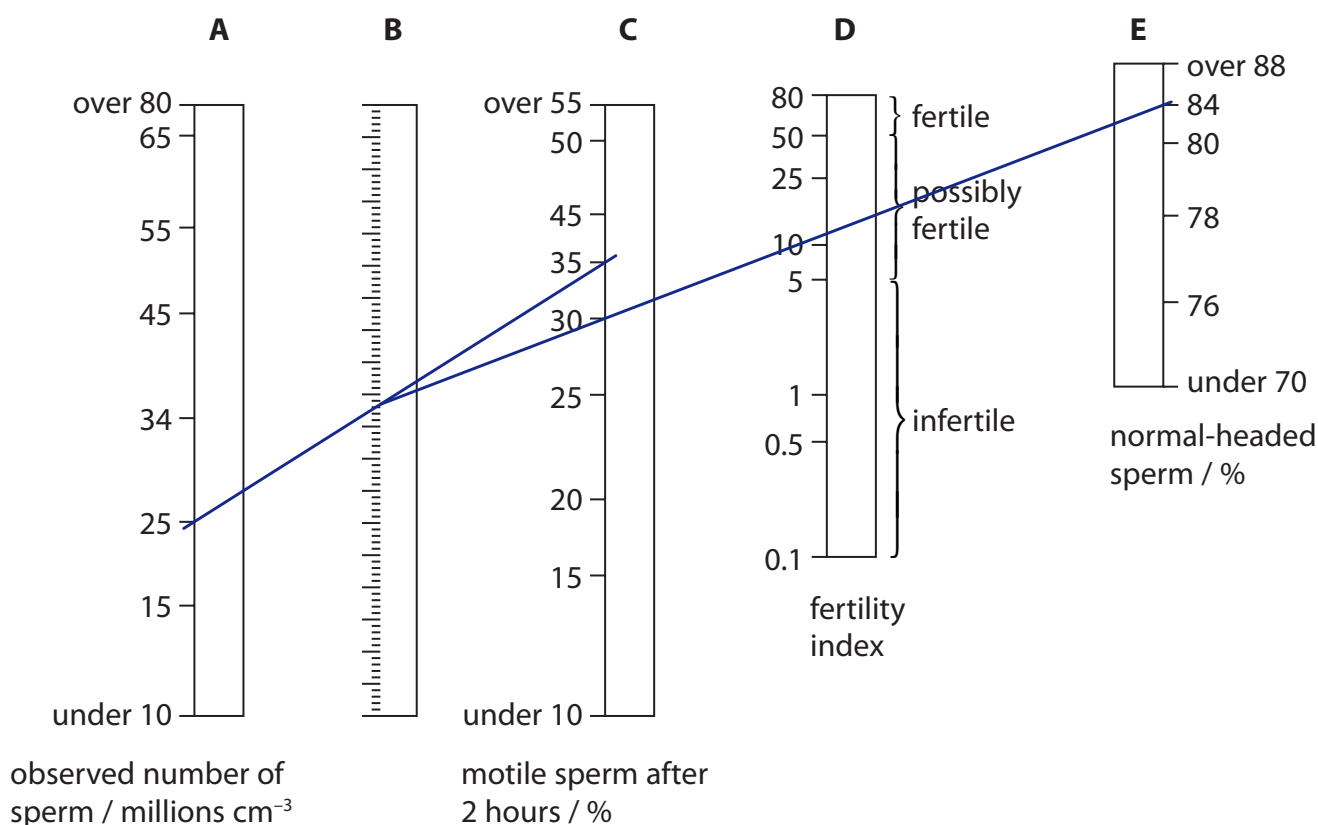
$$\text{speed} = 19 \div 180 = 0.106 \text{ cm min}^{-1}$$

Answer 0.11 cm min^{-1}

- (d) Male fertility can be estimated using scales that take into account the number of sperm, their mobility and the percentage with a normal 'head'.

To calculate male fertility using these scales:

- draw a straight line between the observed number of sperm (scale A) and the percentage of sperm motile after 2 hours (scale C)
- from the intersection of this line with scale B, draw another straight line to scale E (the percentage of normal-headed sperm)
- the point where this second line crosses scale D (the fertility index), provides a relative assessment of fertility.



(i) Estimate the fertility of a man who produces a semen sample with:

- 25 million sperm per cm^3
- 35% of which are motile after 2 hours and
- 84% of which have normal heads.

(2)

*Lines drawn on the scales: fertility index about 12,
which is in the possibly fertile range.*

Answer *possibly fertile*.....

(ii) Deduce why fertilisation is unlikely to occur if there are 5 million spermatozoa per cm^3 .

(1)

*5 million per cm^3 is off the bottom of scale A (under 10), so the man would be
infertile: too few sperm would reach the oocyte for fertilisation.*

(Total for Question 6 = 10 marks)



7 *Streptococcus pneumoniae* is a bacterium that causes pneumonia.

(a) When *Streptococcus pneumoniae* is grown on a culture plate, the bacterial cells produce:

- either smooth, shiny colonies (S-strain)
- or rough colonies (R-strain).

The S-strain bacteria produce a smooth capsule but the R-strain bacteria do not.

(i) Explain why the R-strain bacteria are not able to produce the capsule present in the S-strain bacteria.

(2)

The gene for the capsule is not present (or is mutated) in the R-strain.

So the enzymes (proteins) needed for synthesising the capsule are not produced in the R-strain.

(ii) In an investigation, mice were injected with either the S-strain or the R-strain.

The results are shown in the table.

Strain of <i>Streptococcus pneumoniae</i> injected into mice	Injected mice
S-strain	died
R-strain	lived

The S-strain bacteria were then killed by heating them.

Mice were then injected with either heat killed S-strain bacteria or a mixture of heat killed S-strain bacteria and live R-strain bacteria.

The results are shown in the table.

Strain of <i>Streptococcus pneumoniae</i> injected into mice	Injected mice
S-strain (heat killed)	lived
S-strain (heat killed) and R-strain (live)	died



Analyse the data to explain why the mice died when they were injected with a mixture of heat killed S-strain and live R-strain bacteria.

(3)

Heat killed S-strain alone and live R-strain alone did not kill the mice, so the R-strain was transformed by (picked up something from) the dead S-strain.

Therefore the R-strain now has the genes (DNA) coding for the enzymes (proteins) needed for synthesising the capsule.

Therefore the R-strain now produces a capsule and has become virulent (S-strain), so the mice died.

(b) In another investigation, heat killed S-strain bacteria were treated with **one** type of enzyme:

- protein digesting enzymes (proteases)
- RNA-digesting enzymes (RNAases)
- DNA digesting enzymes (DNAases)
- lipid digesting enzymes (lipases).

Each type of enzyme treated S-strain bacteria was then mixed with live R-strain bacteria and injected into mice.

Complete the table to predict whether the mouse lives or dies.

Write **dead** OR **alive** in the spaces in the table.

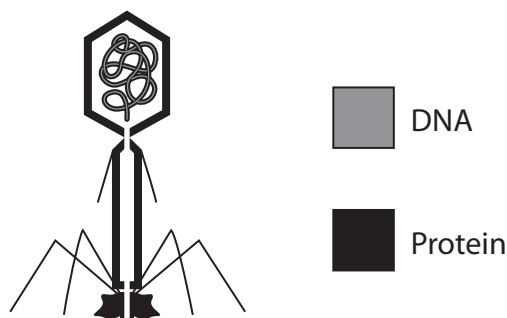
(3)

Enzyme used to treat the heat killed S-strain bacteria	Mouse injected with live R-strain and enzyme treated S-strain [dead or alive]
protease	dead
RNAase	dead
DNAase	alive
lipase	dead



(c) Another investigation used radioactively labelled phages.

Phages are viruses that consist of DNA contained within a protein head.



Phages inject their DNA into a host bacterial cell, but leave the protein heads (called phage ghosts) on the outside of the infected cell.

Two different types of phage were developed by growing the phages in cultures of bacteria in two separate media.

Medium **(A)** contained radioactive phosphorus (^{32}P).

Medium **(B)** contained radioactive sulfur (^{35}S).

Type A phage had DNA that included the ^{32}P .

Type B phage had proteins that included the ^{35}S .

- (i) State why radioactive carbon, nitrogen or oxygen were not used in this experiment.

(1)

Carbon, oxygen and nitrogen are found in both DNA and protein, so the label would not distinguish between them (phosphorus is only in DNA and sulfur only in protein).



- (ii) Separate cultures of the bacteria *E. coli* were infected with either type A or type B phage.

After infection the empty phage heads (phage ghosts) were separated from the bacterial cells.

Each was tested for radioactivity.

Complete the table to show where radioactivity was present (Y) or absent (N).

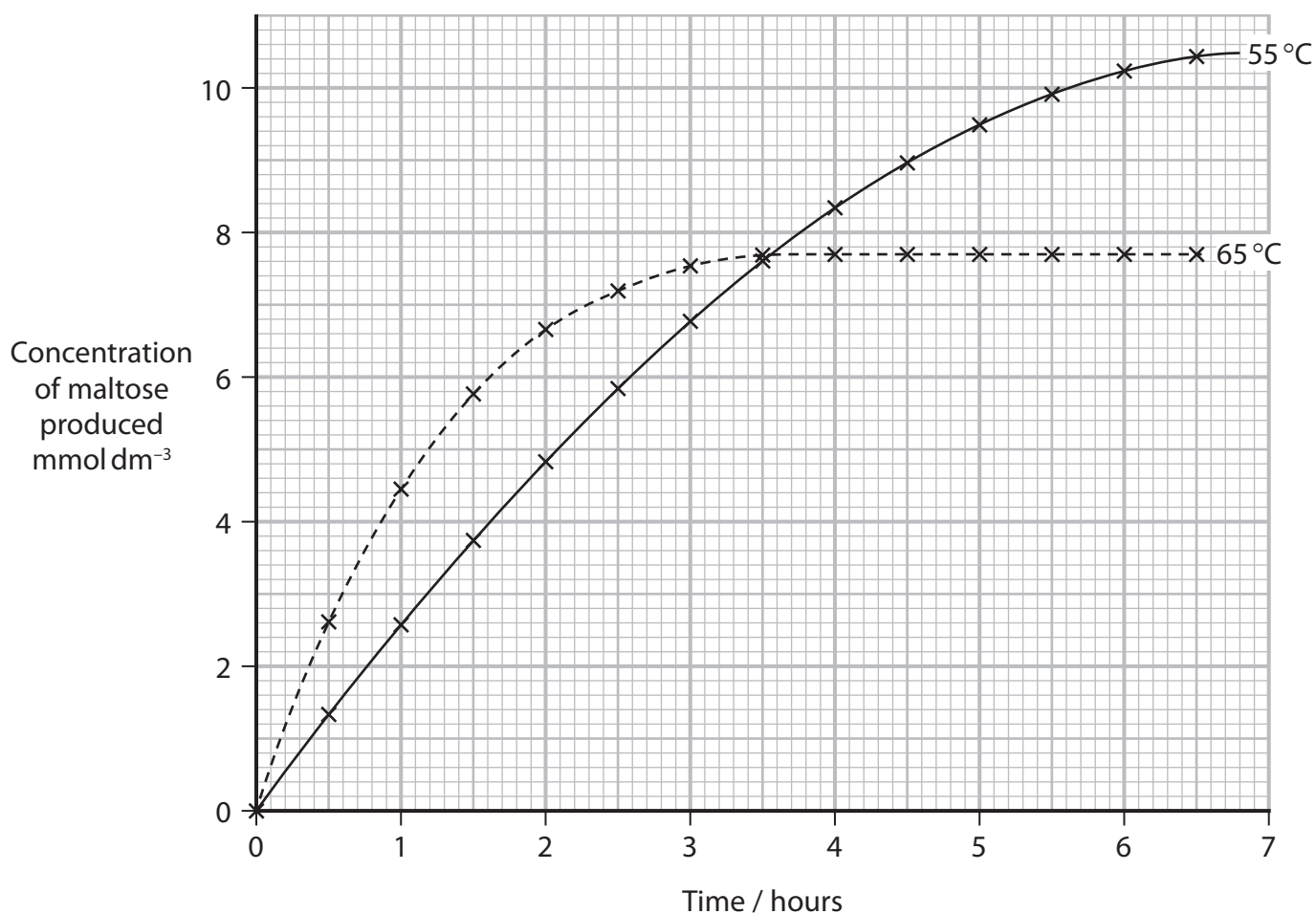
(1)

Phage type (label)	Bacterial cells	Phage ghosts
A (^{32}P)	Y	N
B (^{35}S)	N	Y

(Total for Question 7 = 10 marks)



- 8 The graph shows the results of an experiment investigating the effect of temperature on the hydrolysis of starch using the enzyme amylase.



- (a) Calculate the initial rate of reaction at 55 °C in $\text{mmol dm}^{-3} \text{ min}^{-1}$.

(2)

From the graph at 55 °C, after 1 hour the
concentration of maltose = 2.6 mmol dm^{-3}

1 hour = 60 minutes

initial rate = $2.6 \div 60 = 0.043 \text{ mmol dm}^{-3} \text{ min}^{-1}$

Answer $0.043 \text{ mmol dm}^{-3} \text{ min}^{-1}$

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(b) Explain the difference between the two curves from 4 and 6 hours.

(2)

At 65 °C the enzyme may have denatured, as its active site has changed shape, so no more maltose is produced and the curve levels off at about 7.7 mmol dm⁻³.

This is because the hydrogen bonds (bonding) holding the tertiary structure have been disrupted. At 55 °C the enzyme is not denatured, so maltose is still produced.

(c) In this experiment:

- two beakers were prepared containing 1cm³ of amylase and 100cm³ of starch solution at room temperature
- these beakers were then placed in the water baths at two different temperatures, 55 °C and 65 °C
- every 30 minutes a sample of the mixture was extracted and the concentration of maltose was measured.

(i) Analyse the information to explain why the initial rate of this reaction was faster at 65 °C than it was at 55 °C.

(3)

At the higher temperature the molecules have more kinetic energy.

Therefore there is a greater chance of a collision between the enzyme and the substrate (starch), so there is more chance of an enzyme-substrate complex being formed.

The reaction mixture started at room temperature and was still warming up (had not reached equilibrium) in the water bath, so at the start it was not yet hot enough to denature the enzyme at 65 °C.



*(d) Evaluate the method used in this investigation and suggest improvements.

(6)

The temperature was not controlled at the start, as the enzyme and starch were mixed at room temperature and then put in the water bath. The rate of reaction changes while the mixture warms up, so the initial rate is not at 55 °C or 65 °C. Improvement: put the amylase and starch in separate tubes in the water bath and allow time for them to equilibrate to the temperature before mixing and starting the reaction.

Only two temperatures were tested. Improvement: use a wider range of temperatures, e.g. 20 °C to 80 °C at 10 °C intervals, which would help identify the optimum and the temperature at which the enzyme is denatured.

The pH was not controlled. pH affects the shape of the active site and therefore the rate of reaction, so use a buffer at the same pH in each beaker.

Each experiment was not repeated. Improvement: repeat each temperature at least three times so that a mean can be calculated, anomalies identified and statistical analysis carried out.

Values for the concentrations of amylase and starch, and how the maltose was measured, are not specified. Use the same known concentrations of enzyme and starch at each temperature, and a specified method such as a colorimeter with Benedict's reagent and a calibration curve.

The volume of mixture removed is not stated. Removing samples may alter the concentrations in the reaction mixture, so the same small volume should be removed each time. The same sampling time for both means the same reduction of volume in each mixture.

The enzyme may continue to hydrolyse starch while the maltose concentration is measured, so stop the reaction in each sample immediately, e.g. by boiling it or adding acid.

Sampling every 30 minutes is too infrequent to find the initial rate accurately; more



frequent sampling, e.g. every 5 minutes at the start, would give a more valid initial rate.

A positive feature is that the same volumes of amylase and starch were used in both beakers, so the initial concentrations were the same.

(Total for Question 8 = 13 marks)

TOTAL FOR PAPER = 80 MARKS



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