Name:____ Period:______

AICE Biology: Genetic Regulation of Proteins Problem Set

Answer all questions on this problem set to the best of your abilities. When you are done, check your responses using Ms. Paxson's key. This problem set is worth 30 points and is due the day of your test.

1. What does the process of translation require?

A DNA, free nucleotide bases and mRNA

B DNA, mRNA and RNA polymerase

C mRNA, ribosomes and RNA polymerase

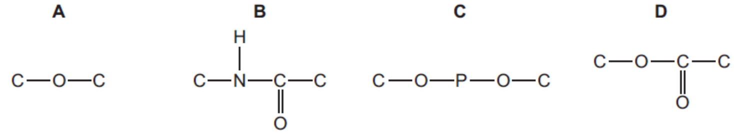
D mRNA, ribosomes and tRNA

2. Which features of DNA enable it to meet these requirements as a molecule of inheritance?

	requirement of DNA molecule			
	ability to remain stable	ability to contain information	ability to transfer information	ability to replicate
A	complementary base pairing	formation of mRNA for translation	sequence of nucleotides	sugar-phosphate backbone
B	formation of mRNA for translation	complementary base pairing	sugar-phosphate backbone	sequence of nucleotides
C	sequence of nucleotides	sugar-phosphate backbone	complementary base pairing	formation of mRNA for translation
D	sugar-phosphate backbone	sequence of nucleotides	formation of mRNA for translation	complementary base pairing

3. Which diagram shows the bond linking the individual units of a nucleic acid?

A **B** **C** **D**



4. In a genetic engineering experiment a piece of double-stranded DNA containing 6000 nucleotides coding for a specific polypeptide is transcribed and translated.

What is the total number of amino acids in this polypeptide?

A 500 **B** 1000 **C** 2000 **D** 3000

5. What makes the exact copying of DNA molecules possible?

A base pairing

B hydrogen bonding between nucleotides

C sugar-phosphate backbone

D the double helix shape

6. Which molecule has its synthesis directly controlled by DNA?

A amylase

B cholesterol

C glycogen

D phospholipid

7. What is the minimum number of hydrogen bonds in a length of DNA containing 700 base pairs?

A 350 **B** 700 **C** 1400 **D** 2100

8. Which term best describes the length of DNA that codes for the synthesis of a polypeptide?

A anticodon

B codon

C gene

D nucleotide

9. Which statements about complementary base pairing are correct?

1 It occurs during translation.

2 Purines and pyrimidines are the same size.

3 The base pairs are of equal length.

4 Uracil forms three hydrogen bonds with adenine.

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 3 and 4 only

10. In a genetic engineering experiment, a piece of double-stranded DNA containing 12×10^3 nucleotides coding for specific polypeptide is transcribed and translated.

What is the total number of amino acids in this polypeptide?

A 6×10^3 **B** 4×10^3 **C** 2×10^3 **D** 1×10^3

11. What is the correct sequence for the processes involved in the formation of an enzyme in a cell?

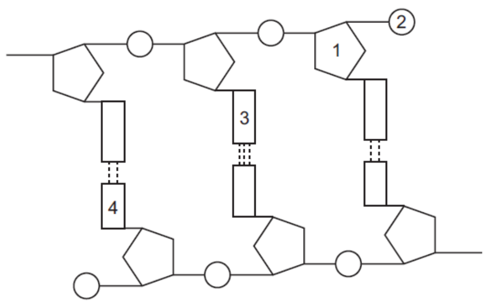
A transcription → condensation → translation → ionic bonding

B translation → hydrogen bonding → transcription → condensation

C transcription → translation → condensation → ionic bonding

D translation → transcription → ionic bonding → hydrogen bonding

12. The diagram shows part of a DNA molecule.



Which row correctly identifies the structures labelled 1, 2, 3 and 4?

	1	2	3	4
A	cytosine	phosphate	guanine	deoxyribose sugar
B	deoxyribose sugar	phosphate	adenine	cytosine
C	deoxyribose sugar	phosphate	cytosine	thymine
D	phosphate	deoxyribose sugar	cytosine	adenine

13. The sequence of nucleotides in DNA in a gene that controls the synthesis of a protein is arranged in triplets, each coding for specific amino acids. The table shows three examples of these triplets.

	triplet code	example
1	DNA code	TAC
2	mRNA code	AUG
3	tRNA code	UAC

Which are the correct codon and anticodon?

	codon	anticodon
A	1	3
B	2	3
C	3	1
D	3	2

14. Which process does **not** occur during the formation of messenger RNA?

A condensation

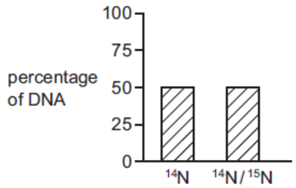
B polymerisation

C replication

D transcription

15. Bacteria were grown in a medium containing ^{15}N. After several generations, all of the DNA contained ^{15}N. Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, ^{14}N. The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amounts of ^{14}N and ^{15}N.

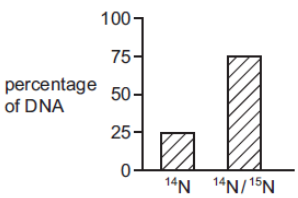
Some bacteria from the medium with ^{15}N were transferred into a medium of ^{14}N. The bacteria were allowed to divide twice. The graph shows the percentages of ^{14}N and ^{15}N in the DNA of these bacteria.



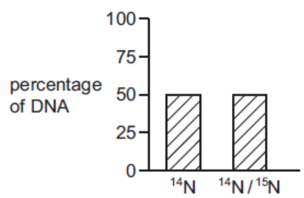
Some bacteria from the medium with ^{15}N were transferred into a medium of ^{14}N. The bacteria were allowed to divide three times.

What would be the percentages of ^{14}N and ^{15}N in the DNA extracted from these bacteria?

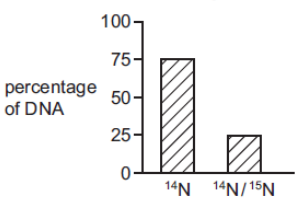
A



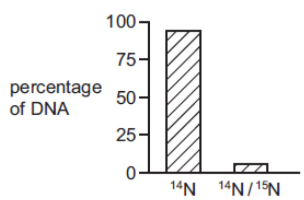
B



C



D



16. Enzymes are ……1…… proteins, made up of polypeptides.

A gene is a sequence of ……2……, which are parts of a ……3…… molecule coding for a polypeptide.

Which words correctly complete gaps 1, 2 and 3 in the sentences?

	1	2	3
A	fibrous	amino acids	tRNA
B	fibrous	bases	DNA
C	globular	nucleotides	DNA
D	globular	triplets	mRNA

17. Haemoglobin is a globular protein consisting of four polypeptide chains – 2 alpha chains and 2 beta chains. In normal individuals, in the DNA which codes for each beta chain, the sixth triplet has a code for glutamic acid.

In individuals with sickle cell anaemia this base triplet changes and codes for valine.

What aspect of the haemoglobin molecule does this mutation change?

A the iron content

B the primary structure

C the quaternary structure

D the secondary structure

18. What is the function of the enzyme RNA polymerase?

A to form a polypeptide using mRNA as a template

B to form a strand of DNA using mRNA as a template

C to form a strand of mRNA using DNA as a template

D to form a strand of mRNA using tRNA as a template

19. The table gives the tRNA anticodons for four amino acids.

amino acid	anticodon (tRNA)
asparagine	UUA
glutamic acid	CUU
proline	GGA
threonine	UGG

A cell makes a polypeptide with the amino acid sequence:

glutamic acid – asparagine – threonine – proline

What was the sequence of bases on the strand of the DNA which was complimentary to the mRNA from which this polypeptide was formed?

A CTTTTATGGGGA

B CUUUUAUGGGGA

C GAAAATACCCCT

D GAAAAUACCCCU

20. The table shows the percentages of bases in DNA from various types of cell.

source of DNA	percentage of bases in DNA			
	adenine	guanine	thymine	cytosine
calf thymus	28.2	21.5	27.8	22.5
bull spleen	27.9	22.7	27.3	22.1
bull sperm	28.6	22.2	27.2	22.0
rat bone marrow	28.7	21.4	28.4	21.5
yeast	31.3	18.7	32.9	17.1

What is a valid deduction from these data?

A All cells from the same species have approximately the same content of DNA.

B Small differences in DNA from different cells have large effects.

C The four bases show complementary base pairing.

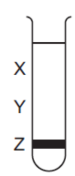
D The structure of DNA is different in yeast and animal cells.

21. Which row shows the correct combination?

	triplet code	codon	anticodon
A	DNA	mRNA	tRNA
B	DNA	tRNA	mRNA
C	mRNA	DNA	tRNA
D	tRNA	mRNA	DNA

22. A culture of bacteria had all its DNA labelled with the heavy isotope of nitrogen (^{15}N). A sample was taken and spun in a centrifuge.

The diagram shows the position of the DNA band at Z in the centrifuge tube.

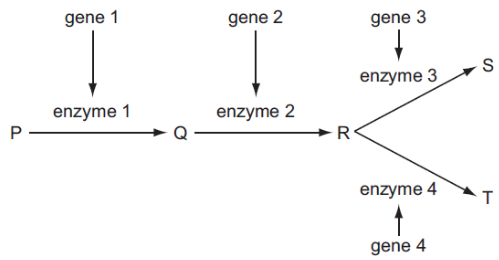


The culture was then allowed to reproduce using nucleotides containing the normal isotope of nitrogen (^{14}N). Samples were taken and spun in a centrifuge after one generation and again after two generations.

In which pattern would the DNA be found after the first and after the second generations?

	after first generation	after second generation
A	half at X and half at Y	quarter at X, quarter at Z and half at Y
B	half at X and half at Z	quarter at X, quarter at Z and half at Y
C	all at Y	half at X and half at Y
D	all at Z	half at Y and half at Z

23. S and T are products of a biochemical pathway. A different enzyme, coded for by different specific genes, catalyses each step in the pathway.



What is the possible outcome to the pathway if a mutation in gene 3 leads to an inactive enzyme?

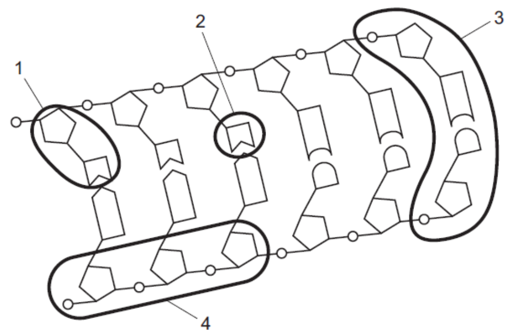
A There is a decrease in the activity of gene 1 and gene 2.

B There is an accumulation of product S.

C There is an increase in the rate of reaction of enzyme 4.

D There is an increase in the production of T.

24. The diagram shows part of a DNA molecule.



Which regions contain phosphate groups?

A 1 and 2 **B** 1 and 4 **C** 3 and 4 only **D** 2, 3 and 4

25. Some antibiotics work by binding to ribosomes and preventing protein synthesis.

Which statement explains why these antibiotics kill bacterial cells but not human cells?

A In bacterial cells mRNA is formed in the cytoplasm from naked DNA.

B Ribosomes in human cells have a different structure from those in bacterial cells.

C The antibiotics cannot pass through human cell surface membranes.

D The tRNA molecules in bacterial cells are different from those in human cells.

26. Which statements about tRNA are correct?

1 contains base pairing

2 contains hydrogen bonds

3 is single stranded

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

27. Which type of sugar and types of bonds are found in a DNA molecule?

	type of sugar	types of bonds
A	non-reducing	hydrogen and ionic
B	non-reducing	hydrogen and peptide
C	reducing	covalent and hydrogen
D	reducing	hydrogen and peptide

28. Which nucleic acid bases are purines?

A adenine and cytosine

B cytosine and thymine

C guanine and adenine

D uracil and cytosine

29. A short piece of DNA 15 base pairs long was analysed to find the number of nucleotide bases in each of the polynucleotide strands. Some of the results are shown below.

	number of nucleotide bases			
	A	C	G	T
strand 1		6		3
strand 2				4

30. How many nucleotides containing guanine were present in strand 1?

A 2 **B** 3 **C** 4 **D** 6

31. The following statements describe events that take place during DNA replication and transcription.

Which statement is **not** correct?

		DNA replication	transcription
A	adenine pairs with thymine	yes	no
B	both DNA polynucleotide chains act as templates	yes	no
C	the original DNA molecule is changed after the process	no	yes
D	uracil pairs with adenine	no	yes

32. A peptide consists of ten amino acids of four different kinds.

What is the theoretical minimum number of tRNA molecules required to translate the mRNA for this peptide?

A 4 **B** 10 **C** 12 **D** 30

33. What does the enzyme DNA polymerase synthesise in a cell?

A a polypeptide using DNA as a template

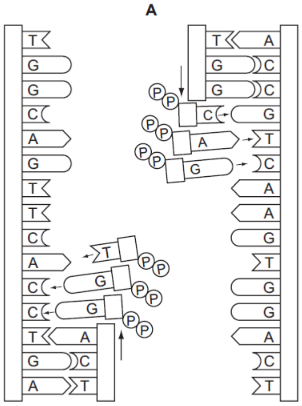
B a strand of DNA using a polypeptide as a template

C a strand of DNA using DNA as a template

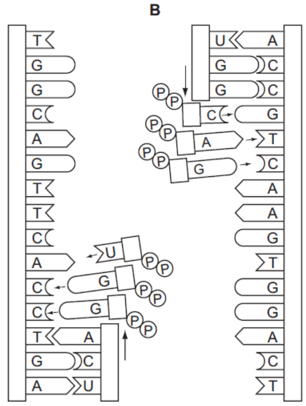
D a strand of mRNA using DNA as a template

34. Which diagram shows the semi-conservative replication of a section of a molecule of DNA?

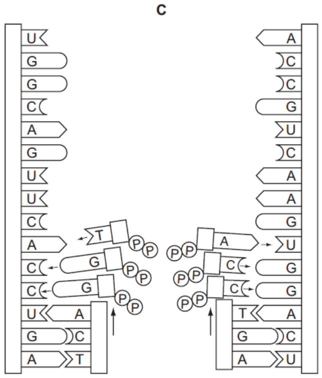
A



B



C



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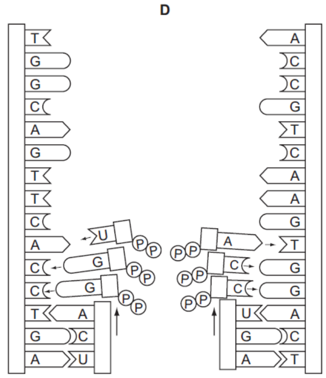

35. Fig. 3.1 shows a molecule of haemoglobin.

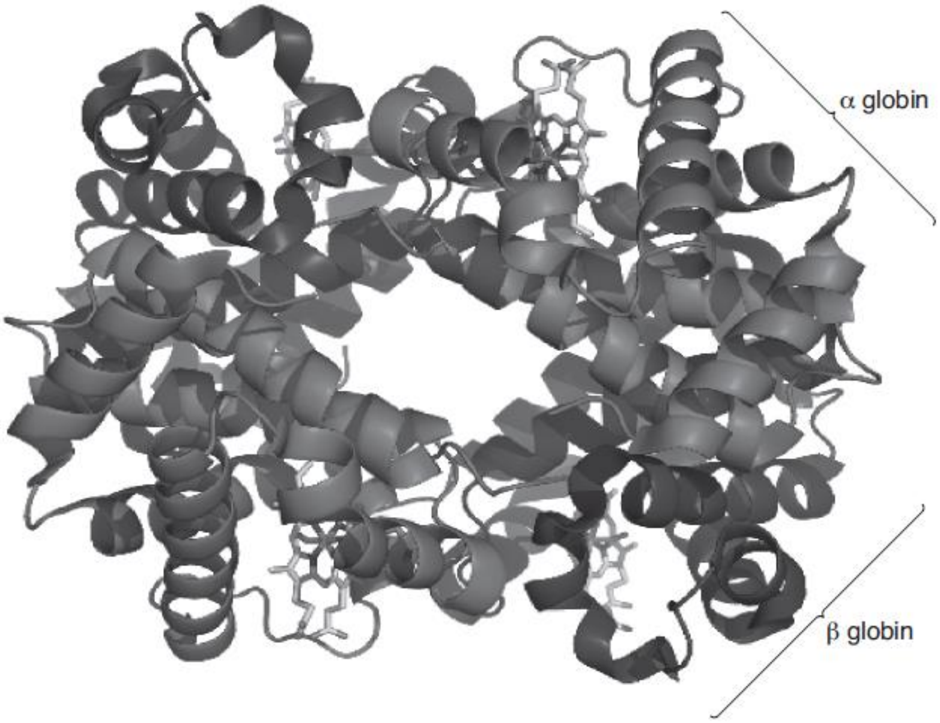

Fig. 3.1

(a) Explain how a molecule of haemoglobin shows the four levels of organisation of protein molecules.

primary structure ....

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....

secondary structure ....

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....

tertiary structure ....

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quaternary structure ....

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....[4]

35. continued...

There are many different variants of haemoglobin. The sequence of bases in DNA that code for the first seven amino acids in two variants of the β-globin polypeptide are shown in Fig. 3.2.

The genetic dictionary for some of the amino acids is in Table 3.1.

Variant 1

1	2	3	4	5	6	7
CAC	GTG	GAC	TGA	GGA	CTC	CTC

Variant 2

1	2	3	4	5	6	7
CAC	GTG	GAC	TGA	GGA	CAC	CTC

Fig. 3.2

Table 3.1

amino acid	**abbreviation**	**DNA triplets on the coding polynucleotide**
valine	val	CAA, CAC, CAG, CAT
proline	pro	GGA, GGC, GGG, GGT
threonine	thr	TGA, TGC, TGG, TGT
histidine	his	GTA, GTG
glutamic acid	glu	CTC, CTT
leucine	leu	AAC, AAT, GAA, GAC, GAG, GAT

(b) Use the genetic dictionary to describe the similarities and differences between the two variants of haemoglobin.

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.... [3]

(c) Collagen is a fibrous protein found in many tissues in animals.

(i) State the function of collagen in the walls of arteries.

....

.... [1]

(ii) State **one** way in which the **structure** of collagen differs from the structure of haemoglobin.

....

.... [1]

[Total: 9]

36. There are many types of amino acids, but only twenty that are polymerised to make polypeptides and proteins in animals.

(a) Name the type of chemical reaction that occurs when two amino acids form a dipeptide.

.... [1]

(b) Fig. 3.1 shows two amino acids, glycine and valine. Use the space below to make a drawing to show what happens when these two molecules join together to form a dipeptide.

glycine valine

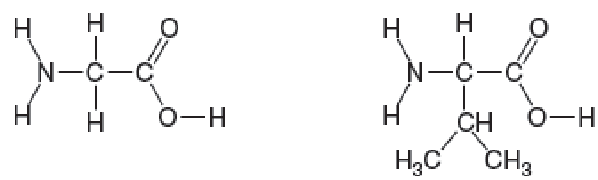

Fig. 3.1

[4]

(c) Angiotensinogen is an inactive protein molecule. When blood pressure decreases, part of angiotensinogen is removed to form a short polypeptide, angiotensin that stimulates an increase in blood pressure.

Fig. 3.2 shows the base sequence within the gene for angiotensinogen that codes for this short polypeptide, the RNA codons and the primary structure of angiotensin.

DNA base sequence	CTA	GCA	CAA	ATG	TAG	GTG	GGG	....
RNA codons	....	CGU	....	UAC	AUC	CAC	CCC	UUC
polypeptide primary structure	Asp	Arg	Val	Tyr	Ile	His	Pro	Phe

Fig. 3.2

(i) Complete Fig. 3.2 to show the missing DNA triplet and the RNA codons. [1]

(ii) State the full name of the type of RNA shown in Fig. 3.2.

.... [1]

37. *Candida albicans* is a yeast-like fungus that lives in human lungs. It is the causative agent of one of the opportunistic infections that may develop during AIDS.

C. albicans is eukaryotic. Fig. 5.1 shows its structure.

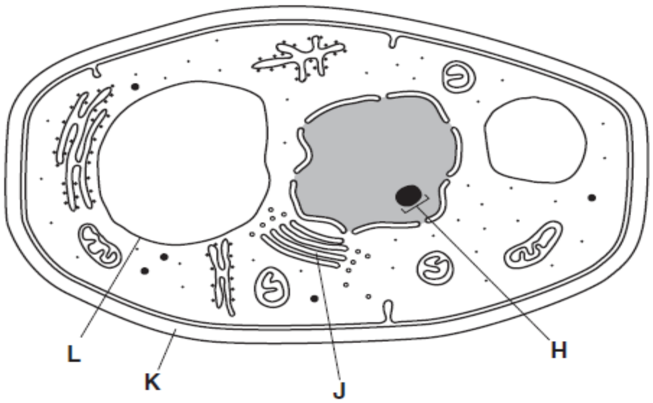

Fig. 5.1

(a) **(i)** Name **H** to **L**.

H ....

J ....

K ....

L ....[4]

(ii) State two ways in which the **structure** of a prokaryotic cell differs from that shown in Fig. 5.1.

1 ....

....

2 ....

....[2]

(b) *C. albicans* uses a transport protein, TMP1, to absorb sugar molecules from the inside of the mouth. TMP1 is encoded by a gene within the nucleus and is produced when sugars are present in the surroundings.

Explain how the structures within the cell shown in Fig. 5.1, are involved with the production of functioning TMP1.

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....[4]

[Total: 10]

38. **(a)** State the structural features of DNA that make it a stable molecule.

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.... [2]

(b) DNA has been described as a 'carrier of coded information'.

Explain this statement.

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.... [2]

(c) State when, during a cell cycle, DNA replication occurs.

.... [1]

(d) There are two alleles of the gene for the β-haemoglobin polypeptide:

- HbA (normal)
- HbS (sickle cell).

Describe **and** explain the difference between the HbA and HbS alleles of this gene.

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.... [3]

38. continued…

(e) DNA polymerase is an enzyme involved in the replication of DNA.

One of the substrates required by DNA polymerase is ATP.

ara-ATP is a chemical that affects DNA polymerase activity.

In an investigation, the effect of different concentrations of ATP on the rate of DNA synthesis was determined:

- with no ara-ATP
- with a low concentration of ara-ATP
- with a high concentration of ara-ATP.

The results of the investigation are shown in Fig. 5.1.

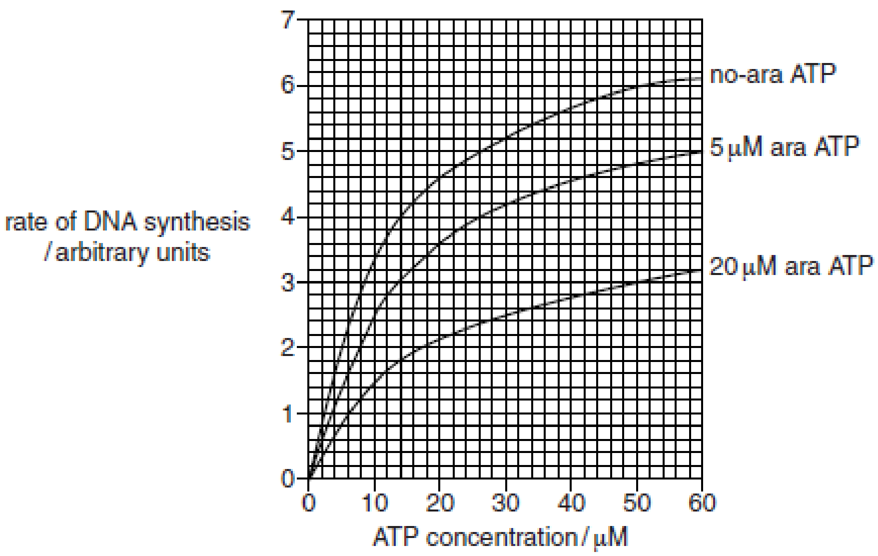

Fig. 5.1

Explain, in terms of the mode of action of enzymes, the results of the investigation shown in Fig. 5.1.

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.... [3]

[Total: 11]

39. High fructose corn syrup, made from maize, can be used as a replacement for sucrose to sweeten food and drink products.

Commercial production of high fructose corn syrup involves the enzyme glucose isomerase, extracted from bacteria.

(a) Fructose and sucrose are both sugars.

State two structural differences between fructose and sucrose.

1 ....

....

....

2 ....

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....[2]

(b) The glucose isomerase used in the production of high fructose corn syrup is extracted from a strain of a bacterium, *Thermus thermophilus*, which is found in hot springs. The enzyme has an optimum temperature of 95 °C.

Suggest **and** explain the advantages of using glucose isomerase from *T. thermophilus* to produce high fructose corn syrup, rather than using glucose isomerase that has an optimum temperature of 37 °C.

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....[3]

39. continued…

(c) The commercial production of high fructose corn syrup uses immobilised glucose isomerase.

Fig. 3.1 shows the effect of pH on the activity of immobilised glucose isomerase compared to glucose isomerase free in solution.

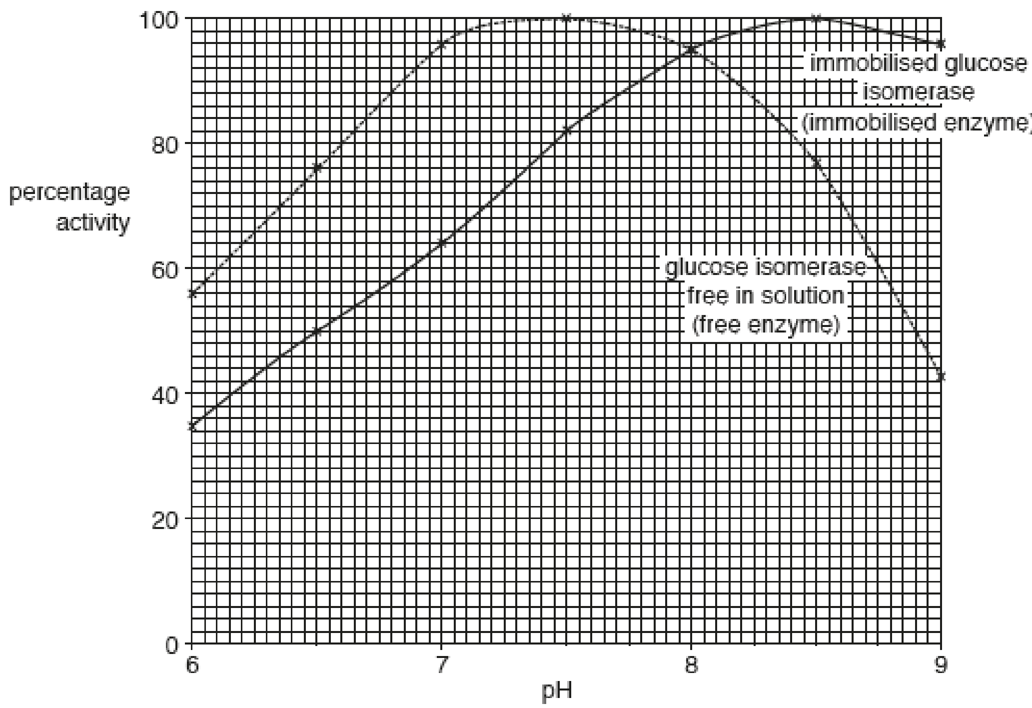

Fig. 3.1

With reference to Fig. 3.1, describe the differences shown between the immobilised enzyme and the free enzyme as pH changes.

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....[3]

39. continued…

(d) The amino acid sequence of the enzyme glucose isomerase has been determined. The first five amino acids of this sequence are shown in Table 3.1.

Table 3.2 (on page 11) shows the genetic code (mRNA codons).

A student was asked to use Table 3.2 to work out an mRNA nucleotide sequence that would correspond to the first five amino acids of glucose isomerase. The student's sequence is shown in Table 3.1.

Table 3.1

amino acid sequence	met	tyr	glu	pro	lys
student's nucleotide sequence	AUG	UAU	GAC	CCU	UGU
correct = ✓ incorrect = ✗					

(i) Complete Table 3.1 using a ✓ or a ✗ to indicate whether the student has used Table 3.2 correctly to identify the codons for each amino acid in the nucleotide sequence. [1]

(ii) Discuss, with reasons, how an mRNA nucleotide sequence worked out to correspond to the first five amino acids using Table 3.2 may not be the same as the mRNA nucleotide sequence for those amino acids present in the bacterial cell.

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....[3]

39. continued…

Table 3.2

first position	second position U	C	A	G	third position
U	phe	ser	tyr	cys	U
	phe	ser	tyr	cys	C
	leu	ser	STOP	STOP	A
	leu	ser	STOP	trp	G
C	leu	pro	his	arg	U
	leu	pro	his	arg	C
	leu	pro	gln	arg	A
	leu	pro	gln	arg	G
A	ile	thr	asn	ser	U
	ile	thr	asn	ser	C
	ile	thr	lys	arg	A
	met	thr	lys	arg	G
G	val	ala	asp	gly	U
	val	ala	asp	gly	C
	val	ala	glu	gly	A
	val	ala	glu	gly	G

[Total: 12]

40. Protein production involves a complex sequence of events and a number of cell structures.

(a) The first column in Table 1.1 shows some of the events that occur in the production of a protein in a cell and its eventual release from the cell.

Table 1.1

event	sequence of events (numbers)	cell location (letters)
exocytosis		
protein modification		
secretory vesicle formation		
transcription		
translation		

(i) In Table 1.1, write the sequence in which the events occur, using **1** as the **first** process in the sequence. [2]

(ii) From the list **A** to **F** below, choose **one** cell location for each event and write the letter in Table 1.1. Each letter may be used once, more than once, or not at all.

A Golgi apparatus
B lysosome
C nucleus
D rough endoplasmic reticulum
E smooth endoplasmic reticulum
F plasma (cell surface) membrane [3]

(b) Describe the process of *exocytosis*.

....

....

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....

....

.... [3]

40. continued...

(c) One example of protein modification is the removal of the first amino acid, methionine, from a newly formed polypeptide chain to make a functioning protein.

(i) The DNA nucleotide sequence that specifies the amino acid methionine is TAC.

State the mRNA nucleotide sequence that is complementary to the DNA sequence for methionine.

.... [1]

(ii) Suggest **two** other ways in which the polypeptide chain is modified to produce the functioning protein.

....

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.... [2]

[Total: 11]

41. Table 5.1 shows the triplets of bases on the template polynucleotide of DNA for some amino acids.

Table 5.1

amino acid		DNA triplets
glutamic acid	(glu)	CTT CTC
histidine	(his)	GTA GTG
leucine	(leu)	GAA GAG GAT GAC
proline	(pro)	GGA GGG GGT GGC
threonine	(thr)	TGA TGG TGT TGC
valine	(val)	CAA CAG CAT CAC

Fig. 5.1 shows the base sequences in DNA and mRNA for the first seven amino acids of the β chain of haemoglobin.

DNA	CAC	....	GAC	TGA	GGA	CTC	CTC
mRNA	GUG	CAC	CUG	....	CCU	GAG	GAG
β chain	val	his	....	thr	pro	glu	glu

Fig. 5.1

(a) (i) Use Table 5.1 to complete Fig. 5.1. [3]

(ii) State the term used to describe the sequence of amino acids in a polypeptide.

.... [1]

(b) In sickle cell anaemia, the amino acid at position 6 in the β chain is valine and not glutamic acid.

Explain how a single change in the DNA triplet for the sixth amino acid of the gene coding for the β chain leads to the production of a different amino acid sequence.

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....[5]

[Total: 9]

42. Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide, a toxic waste product of metabolism.

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

Fig. 3.1 shows the results of an investigation into the effect of hydrogen peroxide concentration on the rate of the catalase-controlled reaction, with and without the presence of two different inhibitors.

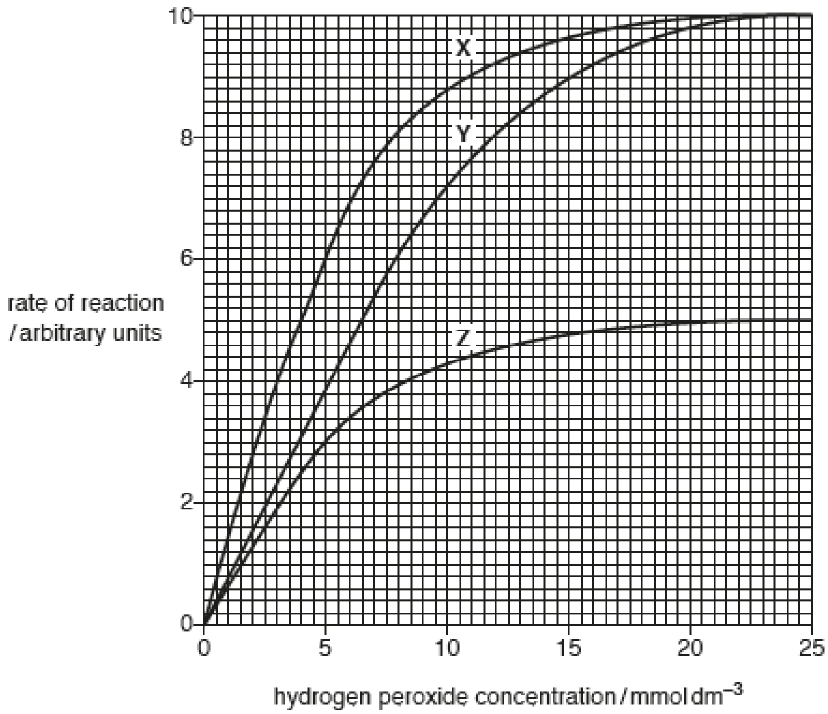

Fig. 3.1

(a) The inhibitors used in the investigation have different modes of action.

Identify which of curves **X**, **Y** and **Z** are the results for:

- the reaction with the non-competitive inhibitor
- the reaction with the competitive inhibitor
- the reaction without any inhibitor.

non-competitive inhibitor ....

competitive inhibitor ....

without any inhibitor ....

[1]

(b) With reference to Fig. 3.1, compare the maximum rate of reaction, V_{max}, and the Michaelis-Menten constant, K_m, for curves **X**, **Y** and **Z**.

V_{max} ....

....

....

....

K_m ....

....

....

....

....

....

[4]

Hydrogen peroxide has a harmful effect on cells. One effect is to damage DNA.

(c) Describe the structure of DNA.

....

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....

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....

....

.... [4]

(d) The cell has mechanisms to repair the damage to DNA caused by hydrogen peroxide. Errors in repair may cause a change to the structure of DNA.

Studies have investigated possible risks associated with foods and drinks that contain hydrogen peroxide. This is because the compound can be considered a mutagen. Mutagens cause mutations.

Explain why hydrogen peroxide can be considered a mutagen.

....

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....

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.... [2]

[Total: 11]