D1.1 DNA replication [40 marks]

1. [Maximum mark: 1]
What is a reason that Taq polymerase is a suitable enzyme for use in the polymerase chain reaction (PCR)?

A. It can work at a wide range of pH.

B. It works at higher temperatures than most enzymes.

C. It can separate two strands of DNA.

D. It allows DNA to be replicated without the use of primers. [1]

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2. [Maximum mark: 1]
Which enzyme is associated with proofreading during DNA replication?

A. DNA primase

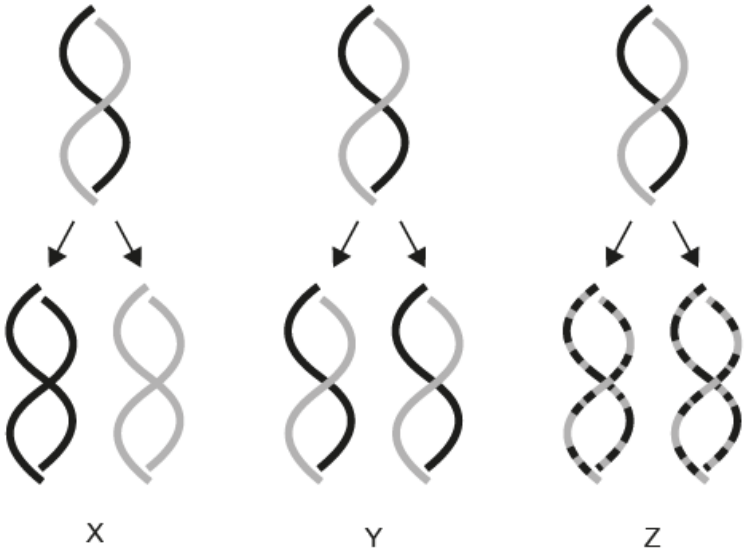
B. DNA helicase

C. DNA polymerase III

D. DNA ligase [1]

3. [Maximum mark: 1]

Which diagram(s) illustrate(s) semi-conservative replication of DNA?



A. X only

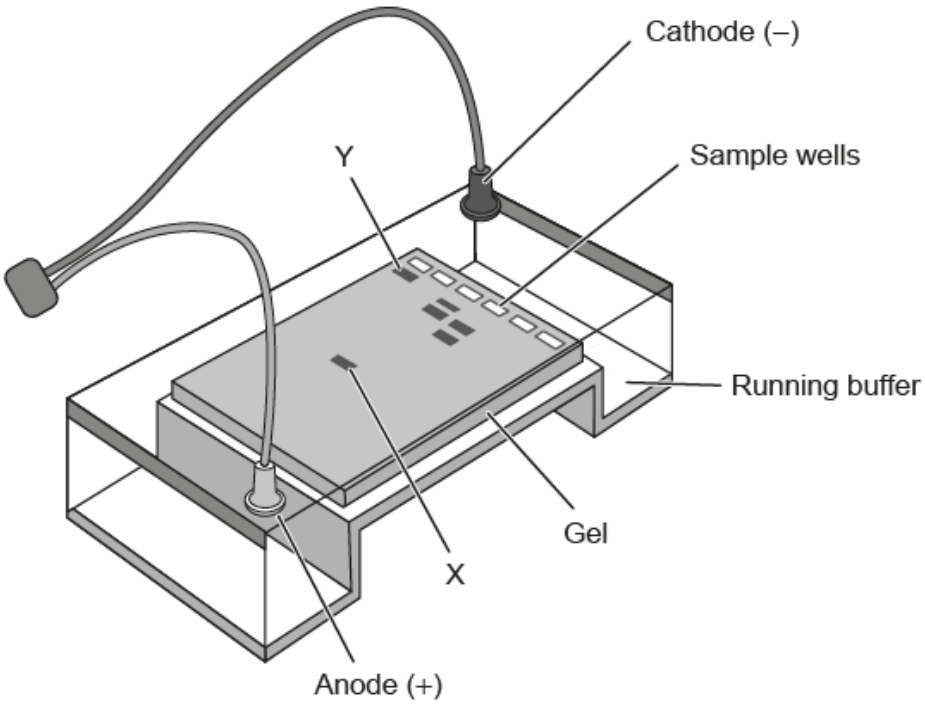
B. Y only

C. Z only

D. X and Y only [1]

4. [Maximum mark: 1]

The diagram shows a gel electrophoresis apparatus.



[1]

What can be deduced from the diagram?

A. X is the smallest fragment.

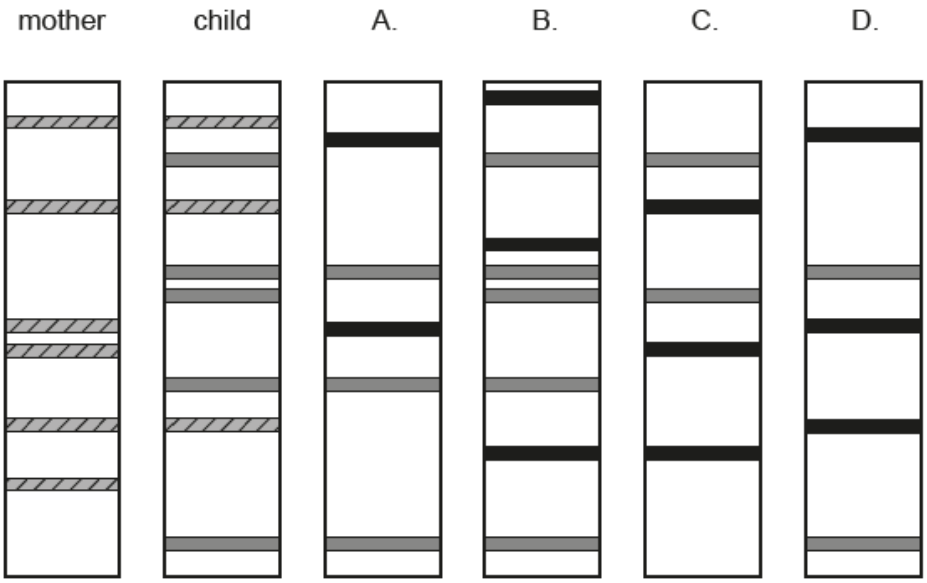
B. Y is positively charged.

C. X is moving towards the cathode.

D. Y travels at the greatest rate.

5. [Maximum mark: 1]

The DNA profile from a paternity test shows six profiles. Who is the child's father?

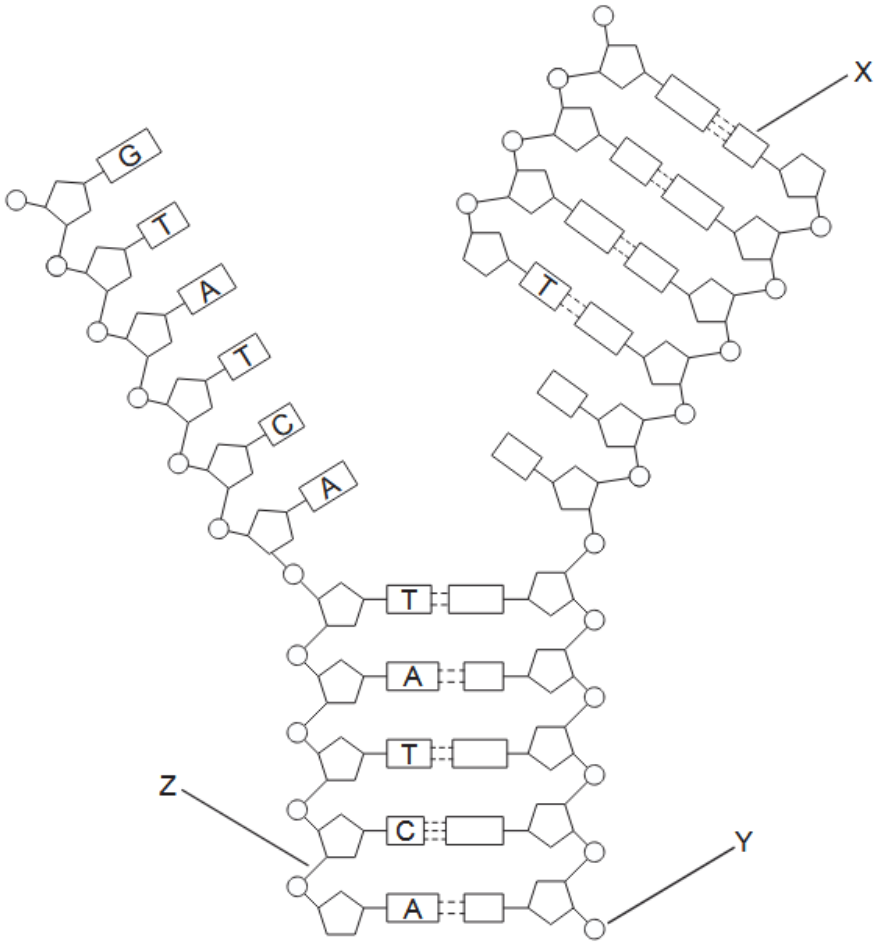


[Source: Helixitta, 2017. DNA paternity testing en. [image online] Available at: https://commons.wikimedia.org/wiki/File:DNA_paternity_testing_en.svg [Accessed 3 June 2024]. Source adapted. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en.]

[1]

6. [Maximum mark: 7]

The diagram shows a nucleic acid, with some of the bases indicated.



(a) Identify the type of nucleic acid shown in the diagram. [1]

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(b) Determine with a reason whether the diagram shows transcription or replication. [1]

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(c) Deduce the base indicated by X on the diagram. [1]

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(d) Identify the terminal indicated by Y on the diagram. [1]

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(e.i) Identify the type of bond indicated by Z on the diagram. [1]

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(e.ii) Several enzymes can catalyse the formation of this type of bond. Explain how **two** enzymes catalyse it during the process shown in the diagram. [2]

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7. [Maximum mark: 1]
What causes DNA to move during gel electrophoresis?

A. DNA is negatively charged, so it is attracted towards the positive electrode.

B. DNA is positively charged, so it is repelled by the positive electrode.

C. DNA is negatively charged, so it is attracted towards positive charges in the gel.

D. DNA is positively charged, so it is attracted towards negative charges in the gel. [1]

8. [Maximum mark: 1]

What is a difference between the leading and lagging strands in DNA replication?

A. Fewer Okazaki fragments are produced on the leading strand.

B. Exons are only produced on the lagging strand.

C. More RNA primers are assembled on the lagging strand.

D. DNA nucleotides are linked 5′ to 3′ on the leading strand and 3′ to 5′ on the lagging strand. [1]

9. [Maximum mark: 1]
In which processes are RNA polymerase and DNA polymerase used?

	RNA polymerase	DNA polymerase
A.	translation	transcription
B.	transcription	translation
C.	transcription	replication
D.	replication	transcription

[1]

10. [Maximum mark: 1]
What is the function of DNA polymerase I in DNA replication?

A. It forms primers by adding short lengths of RNA to the template strand.

B. It removes RNA primers and replaces them with DNA.

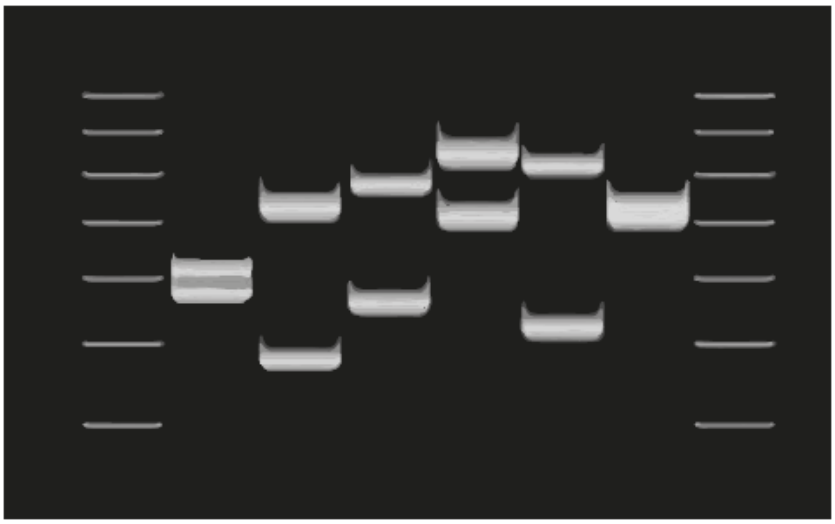
C. It builds the leading strand by adding DNA nucleotides continuously.

D. It forms Okazaki fragments by adding DNA nucleotides on the lagging strand.

[1]

11. [Maximum mark: 1]

The image shows a DNA profile obtained by gel electrophoresis.



[Source: PaleWhaleGail, 2008. https://commons.wikimedia.org/wiki/File:D1S80Demo.png. Licensed under the CC BY-SA 3.0 Deed: https://creativecommons.org/licenses/by-sa/3.0/deed.en. Source adapted.]

What could be found in each band?

A. DNA fragments with the same number of base pairs

B. Several complete DNA molecules of different lengths

C. A complete DNA molecule with a specific charge

D. One DNA strand with a particular base sequence

[1]

12. [Maximum mark: 1]
What is a role of DNA polymerase I during replication of DNA?

A. Form replication forks

B. Remove RNA primers

C. Add short length of RNA to template strand of DNA

D. Add DNA nucleotides to the 5′ end of the new strand [1]

13. [Maximum mark: 1]
What is the role of DNA polymerase during DNA replication?

A. It adds nucleotides to the growing strand.

B. It adds nucleotides to the template strand.

C. It builds messenger RNA.

D. It carries out translation. [1]

14. [Maximum mark: 1]
Which stage of DNA profiling involves the polymerase chain reaction (PCR)?

A. During extraction of the DNA sample

B. During replication of the DNA that has been cut with restriction enzymes

C. During electrophoresis to separate the DNA fragments on a gel

D. During incubation with labelled probes

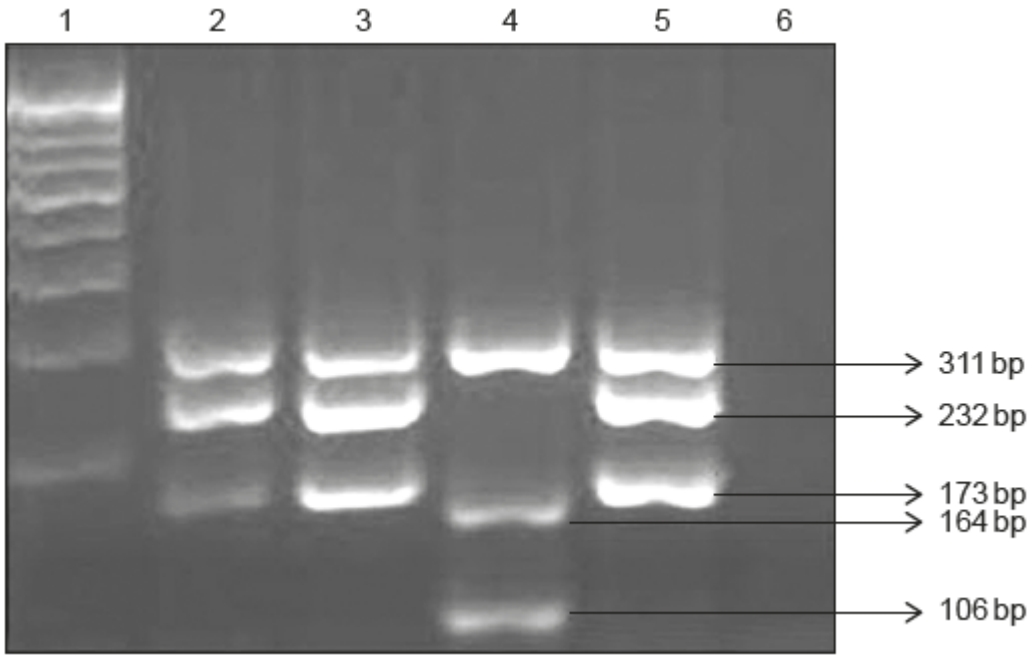
[1]

15. [Maximum mark: 5]

Rapid, low cost detection and identification of influenza virus types and subtypes would be very useful in controlling infections and preventing transmission. A study was conducted to assess the use of reverse transcriptase PCR assays to detect multiple types of influenza A viruses.

Molecular size marker / number of base pairs	Influenza type / subtype
106	A / N1 subtype
164	A / H1 subtype
173	A / N2 subtype
232	A / H3 subtype
311	A / all subtypes

Gel electrophoresis was carried out on the PCR products of different viral samples (lanes 2–6). Lane 1 contains DNA fragments of known size to act as size markers.



[Source: Reprinted from *Indian Journal of Medical Microbiology*, Volume 33, Issue 1, S Dhakad, PC Mali, S Kaushik, AA Lal, S Broor, Comparison of multiplex RT-PCR with virus isolation for detection, typing and sub-typing of influenza virus from influenza-like illness cases, Pages 73–77. Copyright 2015, with permission from Elsevier.]

(a) Suggest the reason that reverse transcriptase PCR was used instead of normal PCR. [2]

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(b) State what is used to visualize the bands on the gel electrophoresis. [1]

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(c) Distinguish between the virus types shown by lanes 3 and 4. [2]

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16. [Maximum mark: 1]

What is the function of the primers in the polymerase chain reaction (PCR)?

A. To separate the two strands of DNA

B. To bind to the complementary strands of DNA

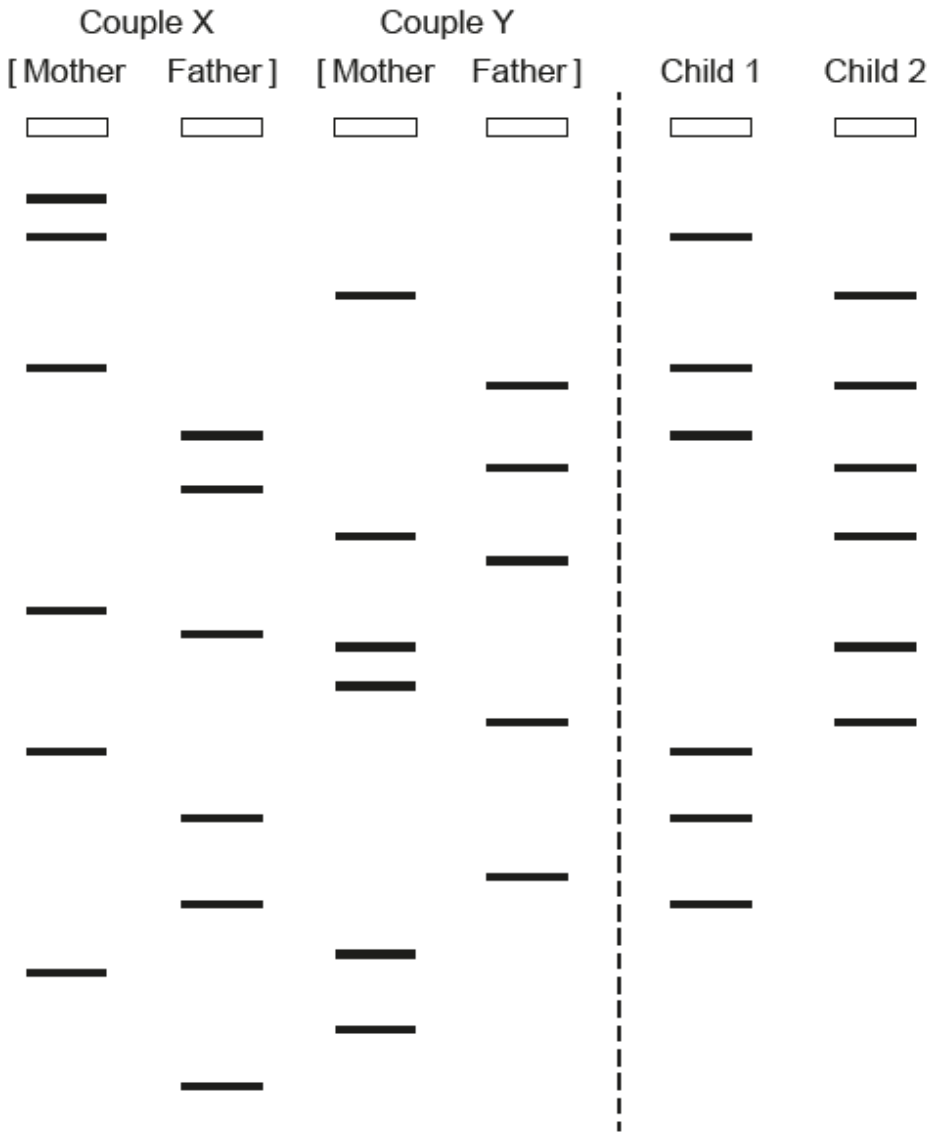
C. To determine the region of DNA that will be copied

D. To activate the *Taq* DNA polymerase

[1]

17. [Maximum mark: 1]

The diagram shows the DNA profile of two couples and two children.



[Source: Barral, M, 2020. *The Birth of Genetic Fingerprinting, an Invaluable Tool for CSI.* [online] Available at: https://www.bbvaopenmind.com/en/science/scientific-insights/the-birth-of-genetic-fingerprinting-an-invaluable-tool-for-csi/ [Accessed 1 September 2022]. Source adapted.]

What is the most probable relationship between them?

A. Couple X are the parents of child 1 and couple Y are the parents of child 2.

B. Couple X are the parents of child 2 and couple Y are the parents of child 1.

C. Couple X are the parents of both children. [1]

D. Couple Y are the parents of both children.

18. [Maximum mark: 1]
What enzyme removes the RNA primers and replaces them with DNA during DNA replication?

A. DNA polymerase I

B. DNA polymerase III

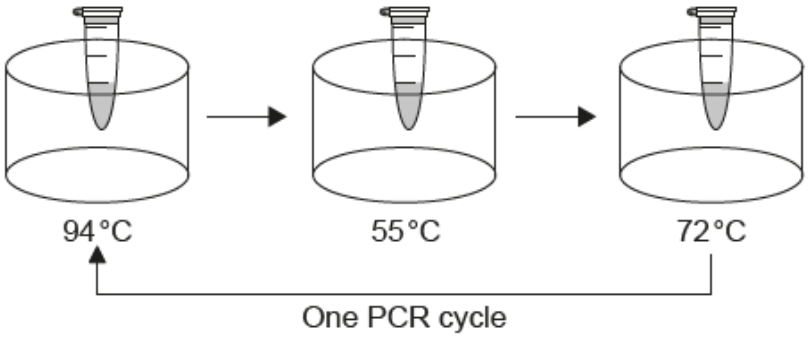
C. DNA gyrase

D. DNA primase [1]

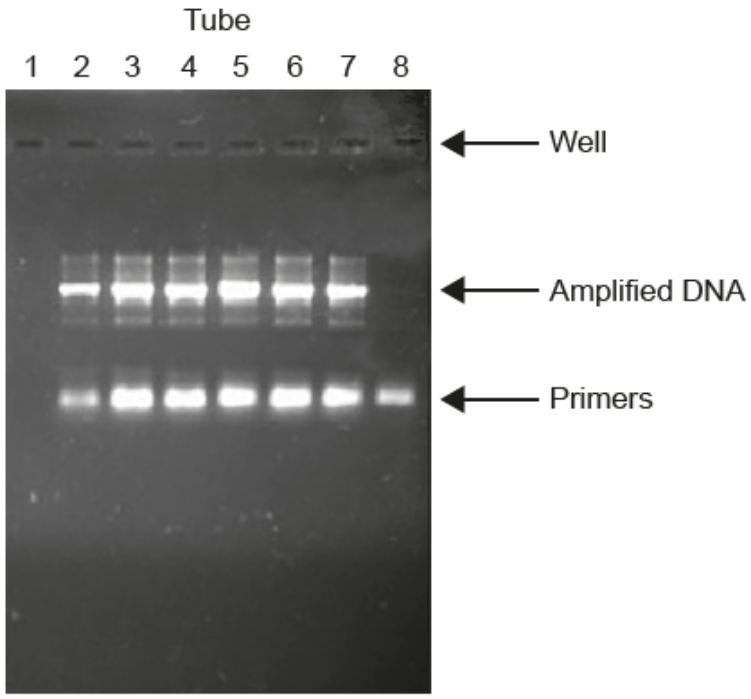
19. [Maximum mark: 5]
A polymerase chain reaction (PCR) was performed to amplify a small amount of DNA. Eight tubes were prepared as shown in the table.

	Mix of nucleotides, salts, buffer and polymerase	DNA	Primers
Control	✓	✓	×
Control	✓	×	✓
Six tubes	✓	✓	✓

The tubes were placed in a thermal cycler with the temperatures shown in the diagram and run for 25 cycles.



The image shows the result of gel electrophoresis on the eight samples.



(a) State the number of the tube used as a control without DNA. [1]

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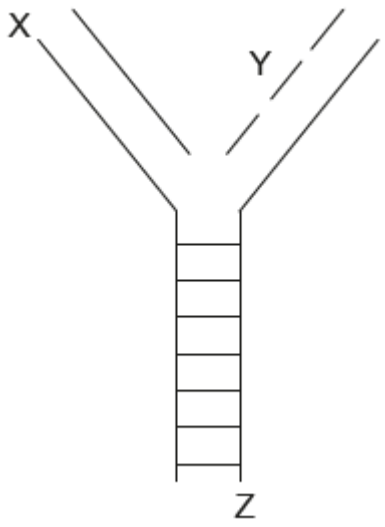
(b) Deduce, with a reason, whether the primers are smaller or larger than the amplified DNA. [1]

(c) Explain the reason for changing the temperature during each cycle. [2]

(d) Predict the result that would be obtained if fewer cycles were used in this PCR process. [1]

20. [Maximum mark: 1]

The image shows a replication fork.



Which row identifies X, Y and Z in the diagram?

[1]

	X	Y	Z
A.	5′ end	DNA leading strand	5′ end
B.	3′ end	Okazaki fragment	3′ end
C.	3′ end	DNA leading strand	5′ end
D.	5′ end	Okazaki fragment	3′ end

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21. [Maximum mark: 1]

What is a function of the enzyme helicase?

A. It coils DNA up into a double helical shape.

B. It links DNA nucleotides in a new DNA strand.

C. It breaks hydrogen bonds between the DNA strands.

D. It forms temporary hydrogen bonds to produce messenger RNA. [1]

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22. [Maximum mark: 1]
Which are two proteins that assist in the unwinding and separation of DNA strands during replication?

A. Helicase and DNA polymerase III

B. DNA gyrase and DNA polymerase I

C. Helicase and DNA primase

D. Single-strand binding protein and DNA gyrase [1]

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23. [Maximum mark: 1]
What is the reason for Taq DNA polymerase being used in the polymerase chain reaction (PCR)?

A. It does not denature at high temperatures.

B. It produces Okazaki fragments more rapidly.

C. It allows translation to proceed rapidly.

D. It works efficiently with helicase in PCR. [1]

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24. [Maximum mark: 1]
What is a function of DNA polymerase I?

A. Adds nucleotides in a 5′ to 3′ direction to elongate the chain

B. Uncoils the DNA double helix and splits it into two template strands

C. Removes RNA primer and replaces it with DNA

D. Produces sugar-phosphate bonds to link Okazaki fragments [1]

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25. [Maximum mark: 1]
What is PCR used for?

A. Separate fragments of DNA by size

B. Amplify small amounts of DNA

C. Compare DNA samples

D. Genetically modify organisms' DNA [1]

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26. [Maximum mark: 1]

What are the functions of DNA primase and DNA polymerase I in DNA replication?

	DNA primase	DNA polymerase I
A.	adds a short DNA primer to the template strand	replaces RNA with DNA in the Okazaki fragments of the leading strand
B.	adds a short DNA primer to the template strand	replaces DNA primers with RNA
C.	adds a short RNA primer to the template strand	replaces RNA with DNA in the Okazaki fragments of the leading strand
D.	adds a short RNA primer to the template strand	replaces RNA primers with DNA

[1]

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