1(a). DNA profiling is used in the investigation of crime and in paternity cases.

State **one** other use of DNA profiling.

_____

--[1]

(b). DNA profiling is an important technique with many uses.

The steps involved in creating a DNA profile can be outlined as follows:

1. DNA extraction
2. Digestion
3. Separation
4. Analysis

When creating a DNA profile from a crime scene, an intermediate step between DNA extraction and digestion, known as PCR, is usually carried out.

The technique of PCR involves a cycle of changes in temperature, shown in the graph.
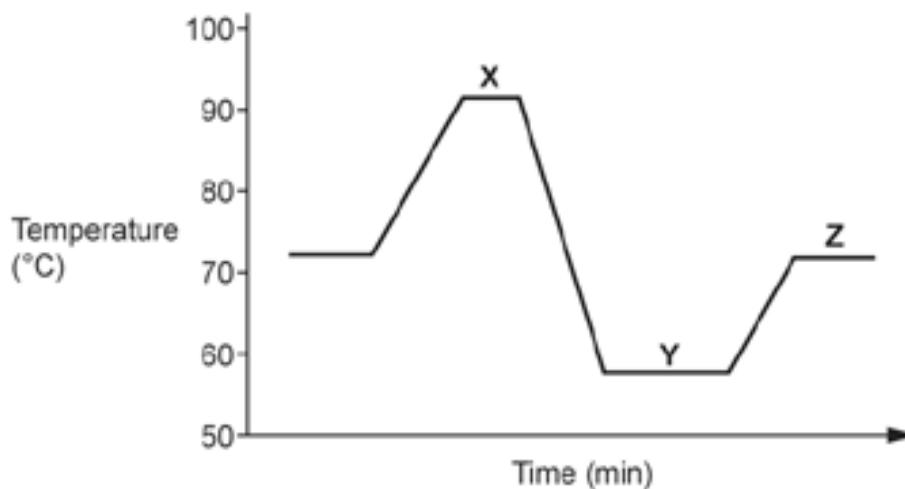
i. Name the technique known as PCR.

--[1]

ii. Outline the process of PCR, with reference to steps **X**, **Y** and **Z**.

X _____

Y _____

Z _____

--[3]

iii.   Explain why a temperature of 72–75 °C is used for step **Z**.

_____

_____

_____

_____

_____

_____

[3]

iv.   Suggest why a PCR step is usually necessary when creating a DNA profile from a crime scene sample in particular.

_____

[1]

(c). This is part of a DNA profile for six loci from a sample of DNA found at a crime scene (E), and DNA from a potential suspect (**S**).

Number of base pairs
100 125 150 175 200 225 250 275 300 325 350 375 400

E

S
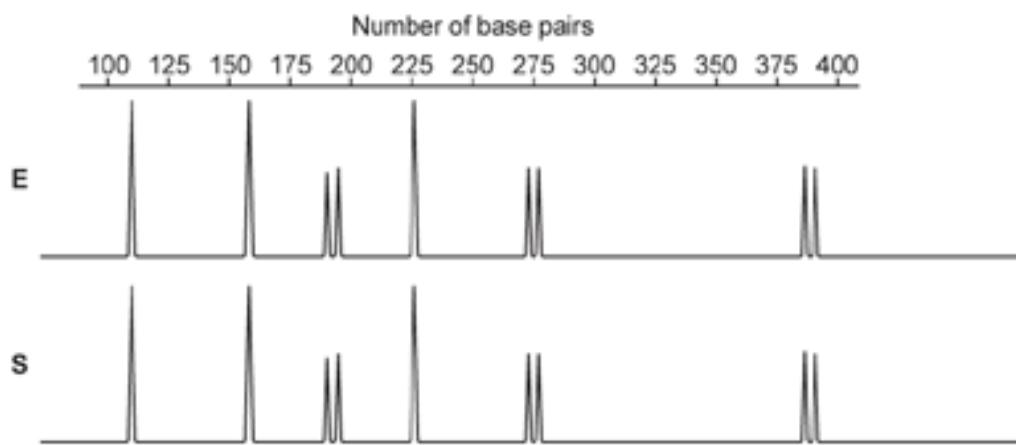
i.   Suggest why some loci have two peaks but some have only one.

_____

_____

_____

[2]

ii.   Using the evidence in the DNA profile it was claimed that suspect **S** had been at the crime scene.

Explain how strongly the evidence supports this claim.

_____

_____

_____

_____

_____

_____

[3]

2. Bioinformatics, computational biology and synthetic biology are relatively new techniques in biology that have a variety of uses. Synthetic biology involves re-designing organisms for useful purposes. One such purpose could be the production of useful proteins.

Proteins can be produced by traditional genetic engineering but the range of proteins available is limited to those that are already produced by a living organism.

Bioinformatics and computational biology can be used in the production of new proteins that are not found anywhere in nature.

i.   Explain how gene sequencing, bioinformatics and computational biology are used in the production of useful proteins in synthetic biology.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

[6]

ii.   Suggest why some people might be concerned about the increase of synthetic biology.

--**[1]**

3. Bacteria can be genetically modified to produce insulin.

i.   State how a plasmid containing the gene coding for insulin can be transferred into a bacterial cell.

--**[1]**

ii.   Suggest how bacterial cells can be screened to check if they have taken up a recombinant plasmid.

--**[1]**

4(a). Genetic modification and selective breeding can be used to improve the characteristics of crop plants, such as maize.
In high light intensity, photosystem II absorbs excess light energy.

A process called nonphotochemical quenching (NPQ) converts the excess light to heat energy.

NPQ can continue when light intensity is no longer in excess. This makes photosynthesis inefficient.

Scientists genetically modified (GM) crop plants to limit NPQ.

The scientists exposed unmodified plants and GM plants to a period of high light intensity followed by lower light intensity. The scientists then compared the rate of NPQ and the rate of carbon dioxide (CO_2) fixation in unmodified plants and GM plants.

Some of the results are shown in the table.

Time after decrease in light intensity (s)	Rate of NPQ (arbitrary units)		Rate of CO_2 fixation (mmol CO_2 m^{-2} s^{-1})	
	Unmodified plant	GM plant	Unmodified plant	GM plant
0	1.00	1.00	26	26
150	0.35	0.25	11.5	13.2

i.   State **one** dependent variable in this investigation.

--**[1]**

ii. Explain the effect of genetic modification on the rate of CO_2 fixation after 150 seconds of low light intensity.

_____

_____

_____

_____

[2]

iii. Often a single company holds the patent for a GM crop plant.

Suggest a potential ethical issue that may exist if one company holds the patent for a GM crop plant.

_____

[1]

(b). Humans have been selectively breeding maize as a crop plant for thousands of years, which has resulted in many different varieties of maize.

Different varieties of maize have different genomes.

Describe how bioinformatics and computational biology can be used to compare the genomes of different varieties of maize.

_____

_____

_____

_____

_____

_____

[3]

5. Haemoglobin is an important protein in many animals, including humans.

Sickle cell disease (SCD) is a disease caused by the production of abnormal haemoglobin.

A treatment for SCD is based on a technique called CRISPR gene editing and allows SCD patients to begin production of fetal haemoglobin.

The treatment has the following steps:

* Bone marrow stem cells are removed from the patient with SCD.
* An enzyme called Cas9 is added to the stem cells.
* Cas9 deletes bases from the *BCL11A* gene.
* The *BCL11A* gene usually switches off the fetal haemoglobin gene in adults.
* The gene-edited stem cells are placed back in the patient.
* The patient can now produce fetal haemoglobin.

This CRISPR gene editing method is different from traditional genetic engineering, which uses restriction enzymes and plasmids.

Describe the similarities and other differences between CRISPR gene editing and traditional genetic engineering methods.

_____

_____

_____

_____

_____

_____

_____

_____

_____**[4]**

6. Gene therapy is a possible future treatment for heart disease.

The *AC6* gene codes for one form of the enzyme adenylyl cyclase.

Clinical trials have tested the effect of increasing levels of the *AC6* gene in heart cells.

   i. Suggest how using gene therapy to increase levels of the *AC6* gene in heart cells may improve heart function.

_____

_____

_____

_____**[2]**

ii.   State **one** method for inserting the *AC6* gene into the heart cells during gene therapy.

---**[1]**

iii.   The results from gene therapy trials are published in peer-reviewed journals.

        State why the results from gene therapy trials are published in journals.

        _____

---**[1]**

7. Some students incubated plasmid DNA with a restriction enzyme.

After 24 h they used gel electrophoresis to analyse the products of the incubation.

Which option shows the correct procedure for gel electrophoresis?

A   Load the sample onto agarose gel → apply voltage for a set time → photograph the gel

B   Load the sample onto agarose gel → apply voltage for a set time → stain the gel → photograph the gel

C   Photograph the agarose gel → load the sample onto gel → apply voltage for a set time → stain the gel

D   Stain the agarose gel → apply voltage for a set time → load the sample onto agarose gel → photograph the gel

Your answer   ☐   **[1]**

END OF QUESTION PAPER