1 The four o'clock plant, *Mirabilis jalapa*, can have flowers of three different colours as shown in Fig. 4.1.

Fig. 4.1

(a) A student crossed some crimson-flowered plants with some yellow-flowered plants (cross 1). She collected the seeds and grew them. All of the plants that grew from these seeds had orange-red flowers.

Complete the genetic diagram to explain the result of cross 1.

parental phenotypes	crimson flowers	×	yellow flowers
parental genotypes	$\mathbf{A^CA^C}$	×	$\mathbf{A^YA^Y}$
gametes	.....	+	.....
offspring genotype		.....	
offspring phenotype		.....	

[3]

(b) The student then carried out three further crosses as shown in Table 4.1.

Table 4.1

	cross	geno of offspring
2	offspring of cross 1 × offspring of cross	
3	offspring of cross 1 × crimson-flowered plant	
4	offspring of cross 1 × yellow-flowered plant	

Complete Table 4.1 by writing the genotypes of the offspring of crosses **2**, **3** and **4**, using the same symbols as in the genetic diagram in **(a)**.

Write the genotypes in Table 4.1.

You may use the space below for any working.

[3]

(c) Flower colour in *M. jalapa* is not an example of the inheritance of dominant and recessive alleles.

Explain how the results of the crosses show that these alleles for flower colour are **not** dominant or recessive.

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..... [3]

Flowers from *M. jalapa* were cross-pollinated.

(d) Explain the difference between self-pollination and cross-pollination.

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..... [2]

(e) Some species of plants are self-pollinated.

Discuss the long-term effects of self-pollination on the evolution of these plants.

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..... [4]

[Total: 15]

2 Haemoglobin is a large protein molecule. The structure of each haemoglobin molecule is controlled by a gene that has two alleles:

- **Hb^A** codes for the normal form of haemoglobin,
- **Hb^S** codes for an abnormal form of haemoglobin.

Red blood cells containing only the abnormal form of haemoglobin become a stiff, sickle shape in conditions of low oxygen concentration. This gives rise to sickle cell anaemia.

(a) Describe the harmful effects on the body of having red blood cells which become sickle-shaped.

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..... [5]

People who are heterozygous for the gene for haemoglobin produce both the normal and abnormal forms of haemoglobin. These people show no symptoms or have very mild symptoms known as sickle cell trait.

(b) (i) Complete the genetic diagram to show how a couple who are both heterozygous may have a child with sickle cell anaemia.

parental phenotypes	sickle cell trait	×	sickle cell trait
parental genotypes	.....	×	.....
gametes	....	+	....

offspring genotypes ....

offspring phenotypes ....

[3]

(ii) What is the chance of a child born to this couple having sickle cell anaemia?

..... [1]

In some parts of the world, up to 25% of the population have sickle cell trait.

(c) State the advantage of having sickle cell trait.

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..... [1]

(d) Discuss whether sickle cell trait is an example of codominance.

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..... [2]

[Total: 12]

3 Two species of beetle, *Tribolium castaneum* and *T. confusum*, can infest and eat stored flour.

In an investigation these two species were kept together in containers of flour under different environmental conditions.

Many identical containers were set up, each with the same mass of flour.

Equal numbers of male and female flour beetles of the two species were put into each container at the start.

The numbers of beetles were counted regularly.

The containers were left until only one species survived.

Table 5.1 shows the percentage of containers in which *T. castaneum* or *T. confusum* were the only survivors.

Table 5.1

environmental conditions	percentage of containers in which only *T. castaneum* survived / %	percentage of containers in which only *T. confusum* survived / %
A hot and wet	100	0
B hot and dry	10	90
C warm and wet	86	14
D warm and dry	13	87
E cold and wet	29	71
F cold and dry	0	100

(a) Compare the survival of the two species of flour beetle in different temperatures and humidities.

Use data from Table 5.1 to illustrate your answer.

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..... [4]

(b) Suggest why only one species survived in each container.

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..... [2]

There is a gene in *T. confusum* which controls body colour.

A represents the dominant allele for red-brown body colour.

a represents the recessive allele for black body colour.

(c) Complete the genetic diagram below to show the colour of beetles produced when heterozygous beetles are crossed with beetles that are homozygous recessive for this gene.

parental phenotypes	.....	×	.....
parental genotypes	.....	×	.....
gametes	....	+	....

offspring genotypes .....

offspring phenotypes .....

ratio of phenotypes .....

[4]

The eyes of *Tribolium* species are usually black. A very small number of flour beetles have white eyes.

(d) Explain how this happens and why they are so rare.

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..... [2]

(e) Insect pests, such as flour beetles, eat the flour and deposit nitrogenous waste in urine and faeces into the flour. This leads to the growth of bacteria and fungi in the flour.

Suggest **and** explain what happens to the nitrogenous waste and the faeces released by the flour beetles.

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[Total: 16]